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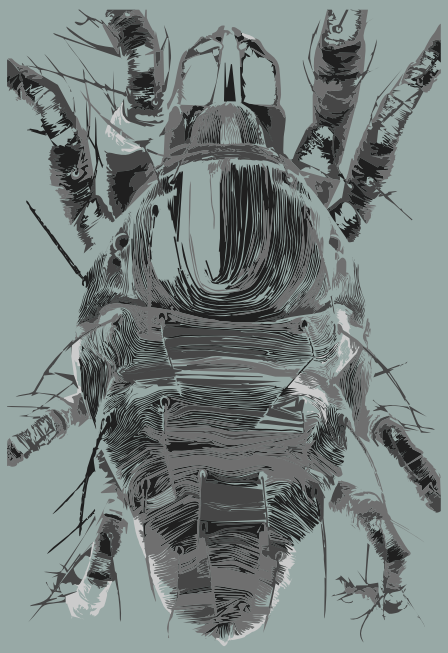

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RESEARCH ARTICLE

Distribution of tick species parasitizing livestock in Sirumalai, The Eastern Ghats of Tamil Nadu, South India and its implications for public health

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ABSTRACT: Ticks and tick-borne diseases are an important public health problem worldwide. In India, prevalence of many tick-borne pathogens such as Ganjam virus, Kyasanur forest disease virus (KFDV), Crimean Congo hemorrhagic fever (CCHF) virus and *Rickettsia conorii* etc., have been documented. The species composition of ticks infesting domestic animals in the Sirumalai area of the Eastern Ghats in Tamil Nadu, South India has been recorded. A total of 2851 tick specimens were collected, and taxonomical identification revealed that 14 species belong to four genera, viz., *Haemaphysalis*, *Rhipicephalus*, *Amblyomma* and *Hyalomma*. Among the species, *Haemaphysalis intermedia* from goats and *Rhipicephalus microplus* from cattle account for 72.6% and 15.2%, respectively. *Amblyomma integrum* was collected only from cattle (*n*=22). *Rhipicephalus simus*, *Rhipicephalus bursa*, *Hyalomma hussaini* and *Hyalomma kumari* have been recorded for the first time this area. The preliminary results confirms the occurrence of rich diversity of tick fauna in this area and recommend further studies to determine the role of these fauna and their public health relevance to livestock and residents.

Keywords: Ixodida, *Haemaphysalis*, *Amblyomma*, *Rhipicephalus*, *Hyalomma*, domesticated animals, South India
Zoobank: https://zoobank.org/29FC14A3-6557-49D0-A32E-AF56BF3D0546

INTRODUCTION

Ticks (Ixodida) are considered as a serious pest of livestock and involved in transmission of various public health important pathogens to animals and humans. Ticks transmit viral, bacterial, and protozoan pathogens to humans and regarded to be the second-most significant vector after mosquitoes (Zhijun et al., 2015). More than 60% of humans are infected due to the pathogens originated through zoonotic (Rahman et al., 2020). The rise in tick-borne diseases globally is a major concern and causes serious illness in humans as well as animals in terms of morbidity, mortality and economic loss (Ghosh and Nagar, 2014; Wikel, 2018). Tick and tick-borne diseases spread due to rapid urbanization, growth of the human population, cattle trade and continuous evolution of pathogens (Chala and Hamde, 2021). The species composition, systematic, and vector incrimination studies are very scarce when compared to mosquitoes. Globally, the Argasidae (soft ticks) and the Ixodidae (hard ticks) together comprise 900 tick species (Abubakar et al., 2018). In India, approximately 106 tick species have been reported (Geevarghese et al., 1997), and the species *Haemaphysalis spinigera* and *H. turturis* are incriminated as vectors of the Kyasanur forest disease virus (KFDV) (Rajaiah, 2019). Likewise, the other species, such as *Rhipicephalus sanguineus, Rhipicephalus* (*Boophilus*) *microplus* and *Hyalomma* spp. acts as vector for *Rickettsia conorii, Babesia bigemina* and Crimean Congo hemorrhagic fever (CCHF) virus respectively (Ghosh and Nagar, 2014). In addition, Indian tick typhus, transmitted by *Rh. sanguineus* and *Rh.* (*Boophilus*) *decoloratus*, Ganjam virus transmitted by *H. intermedia* and *Rhipicephalus haemaphysaloides* are important tick-borne diseases in India (Sudeep et al., 2009; Ghosh and Nagar, 2014; Negi et al., 2021).

In India, though tick faunistic studies have been carried out in different parts of the country (Gurwattan et al., 1975; Geevarghese et al., 1997; Nataraj et al., 2021) the species composition of the tick fauna in many potential areas remains unexplored due to the underreported or unreported tick-borne diseases (Stewart et al., 2017; Salje et al., 2021). In Tamil Nadu, the geography of the Western Ghats and the adjoining areas are found highly suitable for the breeding and existence of ticks. Considering the recent escalating trend of occurrence of ticks and incidences of tick-borne diseases worldwide, this study to map the species composition of ticks from domestic animals in foot-hill villages near the Western Ghats bordering Dindigul and Madurai districts was carried out. Eventually, such data would shed light on the prevalent tick fauna and the possible risk of tick-borne pathogen transmission to humans and animals in this area.

MATERIALS AND METHODS

Study area

The Sirumalai foothill ranges cover 60,000 acres and located in the Eastern Ghats of Tamil Nadu, South India, at longitude 77.9967043, latitude 10.1942441, and elevation 1093m/3586 feet. The details of the study areas where the survey was carried out have been depicted in (Fig. 1). Many rural villages are situated in the foothill's

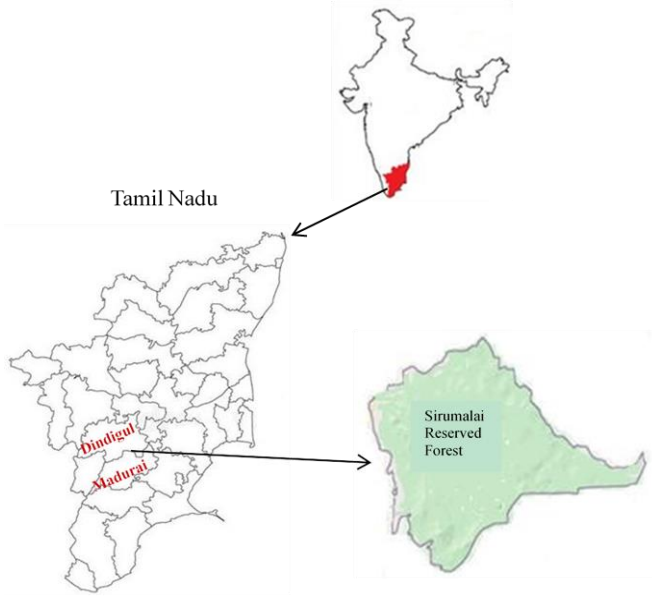

Figure 1. A map of the Sirumalai ticks collected areas.

region of Sirumalai, and house domesticated animals including cattle, sheep, goats, dogs and horses. These domestic animals are often exposed to profuse tick infections while entering the forest areas for foraging. The availability of plenty of vegetation and the existing climatic conditions are highly favorable for the breeding of ticks. This study was duly approved by the Research Institutional Unit (RIU).

Tick Collection and Identification

The ticks were collected from the infested livestock manually using forceps, after obtaining the cattle owner's permission during the daytime. The whole body of the domestic animal, particularly the legs, tail and ears, were thoroughly checked. Before collection, necessary precautionary measures were taken to avoid accidental tick bites. The ticks were collected from cattle, dogs, goats, horses, and sheep. Details of the village, type of host, and date of the collection were labelled on the collection vials. The collected specimens were immediately placed in 70% ethanol in 1.5 ml microtubes and transported to the laboratory for further taxonomic identification. In the laboratory, ticks were grouped by stages and sex before taxonomical identification using a stereo zoom microscope, (Magnus MSZ-TR, India) using standard morphological identification keys as described by (Sharif, 1928; Geevarghese and Dhanda, 1987; Walker et al., 2003; Geevargheese and Mishra, 2011) the genus and species were confirmed. All the taxonomically identified specimens representing species were kept in the institutional tick collection.

RESULTS AND DISCUSSION

A total of 760 domestic animals, viz., goats (*n*=485), sheep (*n*=9), cattle (*n*=237), dogs (*n*=28) and horse (*n*=1) examined, and 2851 tick specimens belonging to various stages were collected. The various stages of ticks collected during the survey included larvae (*n*=86), nymphs (*n*=442), males (*n*=1127) and females (*n*=1196) Table 1. Overall, 14 tick species were recorded from domestic animals, which belonged to 4 genera, viz., *Haemaphysalis*, *Rhipicephalus*, *Amblyomma* and *Hyalomma* (Fig. 3). Among the 14 species, *H. intermedia* and *Rh.* (*B.*) *microplus* account for 72.6%, 15.2%, respectively. The analysis of stagewise tick ratios showed that the females were higher when compared with the males. The hostwise species composition of ticks is depicted in (Fig. 4). The percentage of tick infestation rate among dogs and goats was 57.1% and 54.8%, respectively, followed by cattle (42.6%) and sheep (44.4%) (Fig. 2). The details of the tick species recovered and their vectors potential in the possible transmission of public health important pathogens are presented in Table 2.

The geographical expanding potential of many public health important ticks from their original place of distribution to naive areas and the potential incursion of emerging and re-emergence of tick-borne pathogens is a serious concern globally. According to the estimate, India spends $498.7 million annually to control ticks and tick-borne diseases (TTBD) in domestic animals (Minjauw and McLeod, 2003). Tick-borne diseases are emerging due to climatic changes, rapid urbanization, and human, animal movements etc. (Mourya et al., 2021). The present survey recorded 14 tick species in total in the studied area, the species composition of ticks infesting on domestic animals was indicated. Notable, out of 14 tick species collected 10 of them are well recognized vector of public health importance namely, *Haemaphysalis intermedia*, *H. spinigera*, *H. bispinosa*, *Rhipicephalus haemaphysaloides*, *R. annulatus*, *microplus*, *R. decoloratus*, *R. sanguineus*, *Amblyomma integrum* and *Hyalomma anatolicum*. These tick species have been documented as potential vectors of tick-borne diseases such as Ganjam virus (GANV), Indian tick-typhus, and Anaplasmosis (Negi et al., 2021).

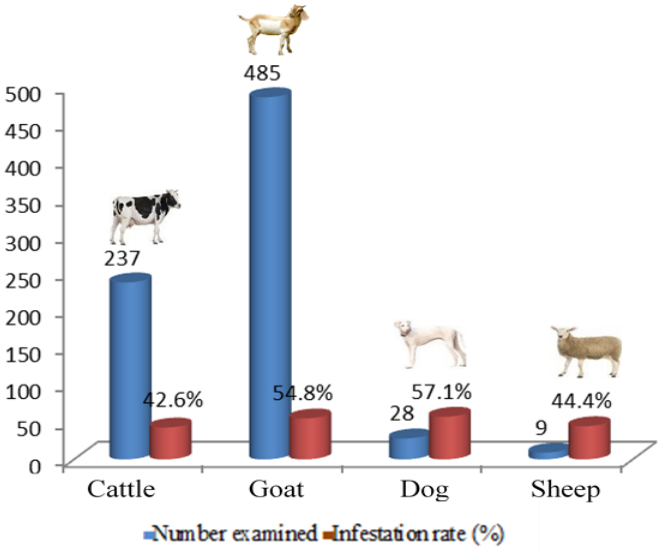

Figure 2. Tick infestation rate in cattle, dogs and sheep.

It is interesting to note that the possible circulation of potential tick-borne pathogens among these vector ticks collected from the study areas. The dominant occurrence (72.6%) of *H. intermedia* in cattle, goats, dogs and sheep indicates that this species has a wider distribution in this area and the availability of specific vertebrate hosts for its

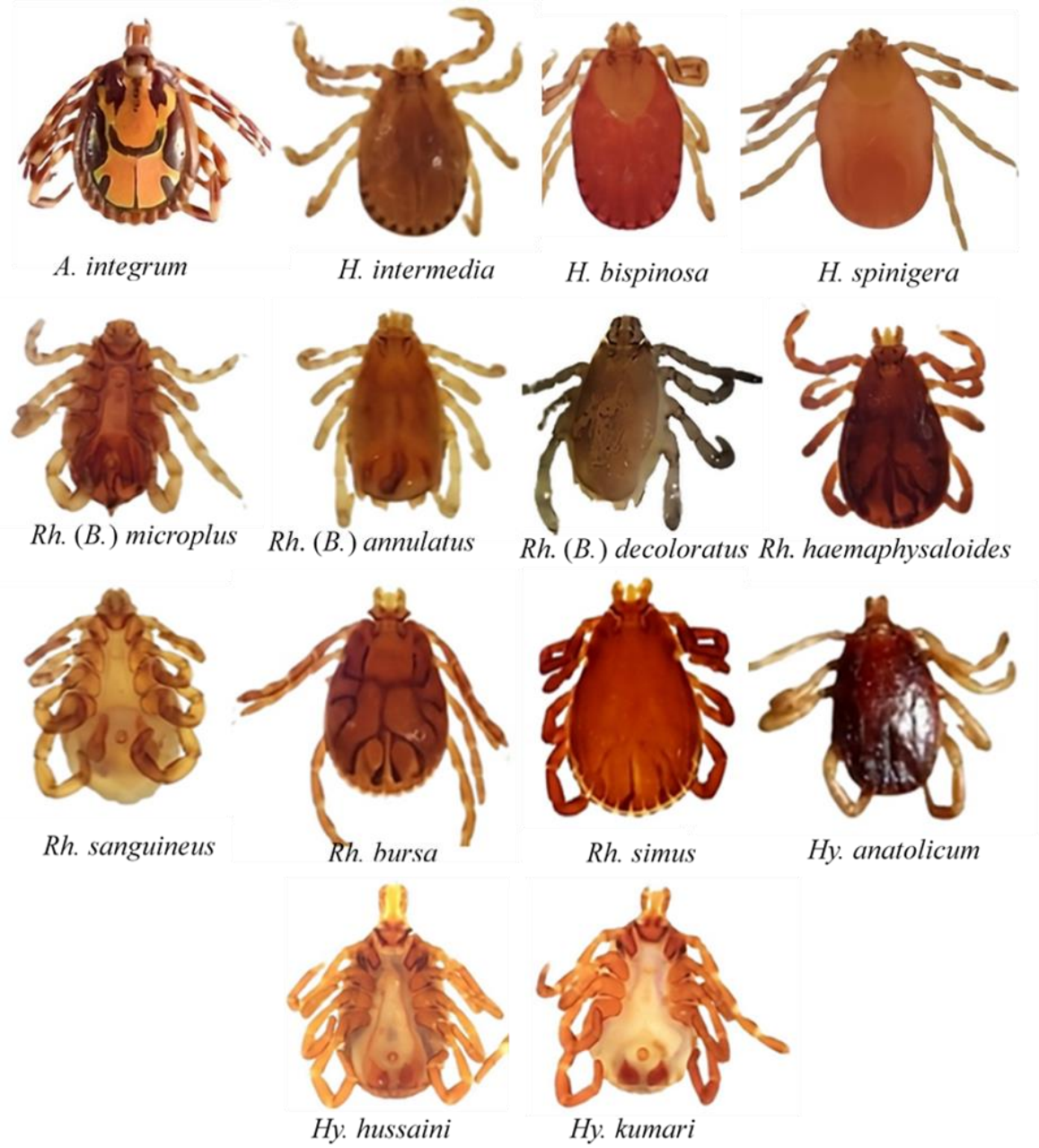

Figure 3. Images of ticks collected from Sirumalai foot hill villages.

feeding and survival. Moreover, the occurrence of *H. spinigera* on cattle and goats and *H. bispinosa* only from goats reveal the availability of a wider variety of host ranges such as birds, cattle and goats (Prakasan and Ramani, 2007). Further, it is noteworthy to understand their association in veterinary and public health in this area, since our recent study have detected laboratory evidences of the circulation of *Rickettsia felis* and *R. raoultii* from *H. intermedia* (Nallan et al., 2023) which have been attributed as the etiological agent of human illnesses namely cat-flea typhus and tick-borne lymphadenopathy (TIBOLA) (Brown and Macaluso, 2016; Mediannikov et al., 2008). However, these vectors *i.e., H. intermedia* has been found transmitting the Nairobi sheep disease virus in Sri Lanka, as well as Bhanja and Ganjam viruses, are new arboviruses in Orissa, India (Perera et al., 1996; Shah and Work, 1969; Dandawate and Shah, 1969). *Rhipicephalus* (*Boophilus*) *microplus* (15.2%) was the most prevalent species recorded in this study and their infestation in cattle causes severe deterioration of animal health and milk production (Jain et al., 2020).

The recording of the *H. spinigera*, a known vector of KFD in India, could indicate the necessity of continuous surveillance for monitoring the possible incursion of KFD viruses in these areas. Although, CCHF cases are not been reported from these areas the recording of *Hy. anatolicum* among cattle, goats and horses recommends strengthening surveillance systems. Every year, 400–500 people in the Western Ghats suffer from diseases transmitted by the *Haemaphysalis* species (Chakraborty et al., 2019). Apart from the potential transmission of viral pathogens by *H. bispinosa*, the data on the possible transmission of other rickettsial pathogens (such as Anaplasmosis), Babesiosis, and tropical Theileriosis are worth understanding as they have already been documented in South-East Asia (SEA) (Senbill et al., 2022).

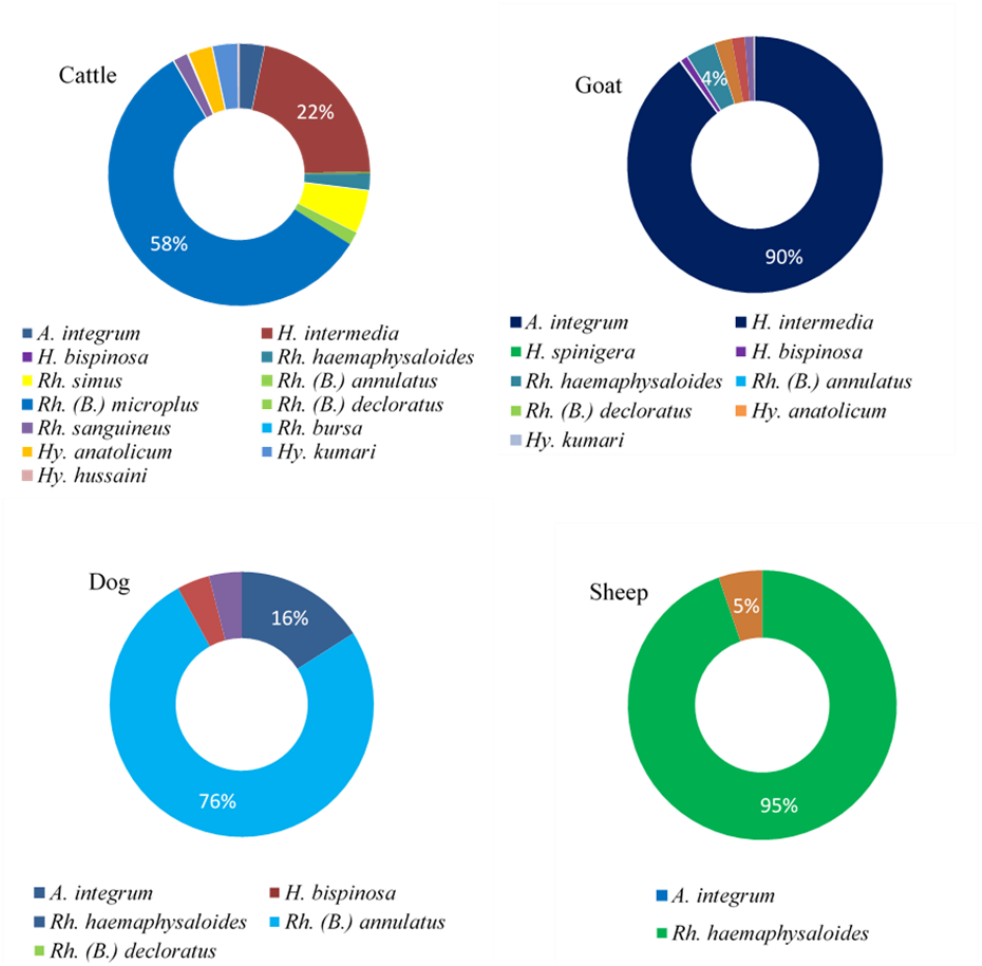

Figure 4. Tick species composition on cattle, goats, dogs and sheep.

Table 1. Details of stagewise tick species collected from animal hosts at Sirumalai

No	Tick species	Ticks stage & gender				Total ticks
		Larva	Nymph	Male	Female	(*n*)
1	*Amblyomma integrum*	0	0	9	13	22
2	*Haemaphysalis intermedia*	85	339	828	818	2070
3	*Haemaphysalis bispinosa*	0	0	15	5	20
4	*Haemaphysalis spinigera*	0	3	1	1	5
5	*Rhipicephalus* (*Boophilus*) *microplus*	0	92	113	228	433
6	*Rhipicephalus* (*Boophilus*) *annulatus*	0	6	4	1	11
7	*Rhipicephalus* (*Boophilus*) *decoloratus*	0	0	1	0	1
8	*Rhipicephalus haemaphysaloides*	0	0	47	50	97
9	*Rhipicephalus sanguineus*	0	0	15	21	36
10	*Rhipicephalus bursa*	0	0	1	0	1
11	*Rhipicephalus simus*	0	0	58	46	104
12	*Hyalomma anatolicum*	1	0	19	5	25
13	*Hyalomma kumari*	0	2	15	8	25
14	*Hyalomma hussaini*	0	0	1	0	1
	Total	**86**	**442**	**1127**	**1196**	**2851**

The prevalence of a significant percentage of *Rh.* (*B.*) *microplus* (58.3%) among the total of 683 ticks, comprising 7 species under the genus *Rhipicephalus* was collected from cattle. This species is considered the most important tick vector since its infection of cattle leads to economic losses in tropical and subtropical regions worldwide (Rodriguez-Vivas et al., 2018). Though the prevalence of *Rh. simus* has been found to be less (3.6%) in this area, the vector has been shown to transmit texas fever (*B. bigemina*) and Anaplosmosis or gall sickness in cattle (*A. marginale*) elsewhere (Tandon, 1990). Interestingly, only *Rh. simus* adult stages were collected from all animals inspected or examined, with a higher infestation rate of 42.3%, 35.5% in goats and cattle, respectively when compared with other animals in this study. Similarly, only adult stages were also recorded

Table 2. Species of ticks collected on domestic animals in the Sirumalai areas, its presence in Indian states and causing diseases.

No	Tick species	Nos collected	Vector-borne diseases	Location	Host	Distributed states in India
1	*A. integrum*	22	Rickettsiosis, Otoacariosis	Dindigul	Cow	6,7,8,10,13,14,16,20,24, 27.
2	*H. intermedia*	2070	Ganjam Virus	Dindigul/ Madurai	Cow, Goat, Dog, Sheep	1,3,4,5,6,7,9,10,11,13, 14,15,18,20,21,24, 28.
3	*H. bispinosa*	20	Kyasanur Forest Disease, Babesiosis	Dindigul	Goat	1,2,3,4,5,7,8,10,11,12, 13,14,15,16,17,19,20, 21,23,24,27.
4	*H. spinigera*	5	Kyasanur Forest Disease	Dindigul	Cow, Goat	1,5,7,13,14,15,16,17, 18,20,24,28.
5	*Rh.* (*B.*) *microplus*	433	Anaplasmosis	Dindigul/ Madurai	Cow, Goat, Dog	1,2,3,4,6,5,7,8,9,10,11, 12,13,15,18,19,20,21, 22,23,24,25,26,27.
6	*Rh.* (*B.*) *annulatus*	11	Anaplasmosis, Babesiosis	Dindigul	Cow	8,11,13,14,24.
7	*Rh.* (*B.*) *decoloratus*	1	Indian tick typhus	Dindigul	Cow	9,11,14.
8	*Rh. haemaphysaloides*	97	Anaplasmosis, Babesiosis	Dindigul/ Madurai	Cow, Goat, Dog	1,2,3,4,5,6,8,9,10,11,12, 13,14,15,16,17,18, 20,21,22,24,27.
9	*Rh. sanguineus*	36	Rocky Mountain & Mediterranean spotted fever	Dindigul/ Madurai	Cow, Goat, Dog	1,2,3,4, 5,8,9,10,11, 12,13,14, 15, 16,19, 20,21,22,24,25,27.
10	*Rh. bursa*	1	Anaplasmosis, Babesiosis	Dindigul	Cow	29.
11	*Rh. simus*	104	East Coast Fever of Cattle, Swine babesiosis,	Dindigul/ Madurai	Cow, Goat, Dog, Sheep Horse	29.
12	*Hy. anatolicum*	25	Crimean Congo Hemorrhagic Fever	Dindigul	Cow, Goat, Horse	1,3,4,5,6,7,8,9,10,11,13, 15,16,20,21,22,24,25,26, 27.
13	*Hy. kumari*	25	Crimean-Congo hemorrhagic fever virus	Dindigul	Cow, Goat	3,4,6,9,10,11,12,14,16, 20,21,22, 25.
14	*Hy. hussaini*	1	Rickettsiosis	Dindigul	Cow	1,4,5,6,8,9,10,11,12,13, 15,16,20,21,22,23,24,25.

1. Andhra Pradesh, 2. Arunachal Pradesh, 3. Assam, 4. Bihar, 5. Chhattisgarh, 6. Delhi, 7. Goa, 8. Gujarat, 9. Haryana, 10. Himachal Pradesh, 11. Jammu and Kashmir, 12. Jharkhand, 13. Karnataka, 14. Kerala, 15. Madhya Pradesh, 16. Maharashtra, 17. Manipur, 18. Meghalaya, 19. Mizoram; 20. Odisha, 21. Punjab, 22. Rajasthan, 23. Sikkim, 24. Tamil Nadu, 25. Uttar Pradesh, 26. Uttarakhand, 27. West Bengal, 28. Andaman and Nicobar Island, 29. Puducherry.

from cattle in Puducherry and presence of this species was confirmed with the DNA partial gene sequencing of ribosomal mitochondrial and 18s rDNA gene (GenBank Acc. No. MW078976 and MW078984) respectively (Nataraj et al., 2021). Another record of *Rh. bursa* (Sharif 1928; Nataraj et al., 2021), the vector of *A. marginale*, *B. bigemina*, *B. motasi*, and *B. bovis* to animals has already been recorded in south India and found distributed in southern Europe, the Near and Middle East. To the best of our knowledge, this study has recorded the prevalence of two public health important species, viz., *Rh. bursa* and *Rh. simus,* as reported earlier (Sharif, 1928; Nataraj et al., 2021) in India. In the earlier study, the vectorial role of *Rh. simus* in the transovarial transmission of *B. trautmanni,* which causes swine babesiosis, has been experimentally demonstrated (Waal et al., 1992). In the present study, we collected *Amblyomma integrum* specimens from cattle. This is the second record in Tamil Nadu. The first occurrence of the tick was recorded in 2017 from a dead bison at Gudalur, the Nilgiris, Tamil Nadu, India (Soundararajan et al., 2017). Since this species freely feeds on wild and domestic animals as well as humans, it can act as a zoonotic vector (Apanaskevich et al., 2016). It transmits *T. annulata*, the apicomplexan parasite, and 250 million cattle are at risk due to the infection of this parasite through the tick vector (Liu et al., 2022). Serological studies on the subclinical to severe clinical outbreaks of bovine tropical theileriosis in cross-bred cattle have been reported in the states of Karnataka, Orissa, Tamil Nadu, Kerala, Uttarkhand, and Punjab (Edith et al., 2018).

A male *Hyalomma hussaini* was collected from horse whereas *Hy. anatolicum* and *Hy. kumari* were collected in equal proportions from cattle and goats. The second two species were known to cause Crimean Congo

Hemorrhagic Fever (CCHF) and *Trypanosoma* (*Megatrypanum*) *theileri*, a weak pathogenic parasite of domestic cattle (Shastri and Deshpande, 1981). These three species were recorded among cattle and sheep in Maharastra state during the ixodid survey in 1976-1978 (Geevarghese and Dhanda, 1995). Information on the prevalence of these species in other states is scanty.

Ticks and tick-borne diseases have become a serious public health problem globally. Ticks are serious livestock pests, they remain the major cause of economic impact. Apart from the country's economic damage, they also transmit various pathogens. Under this scenario of emerging the tick-borne diseases, the current survey described the species composition of tick fauna on domestic animals in Tamil Nadu southern region. The dominant occurrence of *H. intermedia* in the area is unique, and there is a possible public health risk of transmission of pathogens both in humans and animals. The first-ever recording of *Amblyomma* spp. in this area and determining their risk are also worth studying in future. The first-time recording of *Hyalomma* spp., in these areas also paves the way for further studies in order to determine the interaction with the host and humans. The outcome of the pilot study would corroborate the occurrence of important tick fauna in the studied area, which would complement existing knowledge on ticks in screening the tick-borne pathogens and the potential risk of tick-borne diseases.

Authors' contributions

Veerapathiran Ayyavu: Conceptualization, investigation, methodology, data curation, writing original draft. **Krishnamoorthy Nallan:** Investigation, methodology, data curation, draft, review & editing. **Elango Ayyanar:** Taxonomic identification, image processing of ticks, writing original draft. **Balaji Thiruppathi:** Resources, methodology, draft editing. **Ashwani Kumar:** Critical evaluation of the study, supervision, funding acquisition. **Paramasivan Rajaiah:** Conceptualization, project administration, review & editing.

Statement of ethics approval

This study has been approved by the institutional Research Integrity Unity (RIU) of the Vector Control Research Centre, RIU-05/2022.

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Conflict of interest

The authors declare no conflict of interest.

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RESEARCH ARTICLE

A new species of *Promicrodispus* (Acari: Microdispidae) from the Altai Republic, Russia

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ASBTRACT: A female of *Promicrodispus altaicus* Khaustov sp. nov. (Acari: Heterostigmata: Microdispidae) is described from the forest litter sample collected from vicinity of the Teletskoye Lake in Altai Republic of Russia. The new species is very similar to *P. pumilis* (Sevastianov), but it can be distinguished by the presence of setae *ps2* and lacking of seta *s* on tibiotarsus of leg I. Using of SEM microscopy revealed previously unknown structure in gnathosoma of the new species. A key to the species of *Promicrodispus* is also provided.

Keywords: Pygmephoroidea, systematics, morphology, key, Western Siberia, SEM microscopy
Zoobank: https://zoobank.org/EA5DAD30-085C-4887-9142-C7F4CFAD1A80

INTRODUCTION

The family Microdispidae Cross, 1965 is the least diverse family of pygmephoroid mites (Acari: Pygmephoroidea), and comprises 28 genera and about 130 described species (Khaustov and Khaustov, 2023; Rahiminejad et al., 2023). Most microdispid mites are fungivorous, however, some species from the genera *Perperipes* Cross, 1965, *Glyphydomastax* Cross, 1965 and *Peponocara* Cross, 1965 are probably parasitoids of insects (Kaliszewski et al., 1995), and the recently described monotypic genus *Sidorchukdispus* Khaustov et al., 2019 most likely includes external parasites of termites (Khaustov et al., 2019). Khaustov (2018) provided the latest key to the genera of Microdispidae. Microdispid mites of Asian Russia are poorly studied. At present 11 species of 6 genera have been recorded in Western Siberia, namely: *Caesarodispus samsinaki* (Mahunka, 1967), *C. brevipes* Mahunka, 1981, *C. minutus* (Sevastianov, 1981), *Pseudomicrodispus setosus* (Evans, 1952), *Promicrodispus pumilis* (Sevastianov, 1975), *Unguidispus contematosus* Sevastianov, 1981, *U. japonicas* Kurosa, 1979, *U. lasii* Kurosa, 1979, *U. polyctenus* (Sevastianov, 1969), *Neomicrodispus sibiriensis* Khaustov, 2018, and *Premicrodispus* (*Premicrodispulus*) *kurganiensis* Khaustov and Khaustov, 2023 (Khaustov, 2014, 2016a, b, 2017; Khaustov and Khaustov, 2023). Nothing is known about Microdispidae of Altai.

The genus *Promicrodispus* Khaustov, 2017 comprises four described species: *P. pumilis*, *P. fageus* (Rack, 1965), *P. salinus* Khaustov and Trach, 2022 from the Palaearctic, and *P. bisetus* Khaustov and Minor, 2020 from New Zealand (Rack, 1965; Sosnina and Sevastianov, 1975; Khaustov, 2017; Khaustov and Minor, 2020; Khaustov and Trach, 2022)). Here we describe a female of *Promicrodispus altaicus* sp. nov. collected from the forest litter sample in Altai Republic of Russia.

MATERIALS AND METHODS

Mites were extracted from the forest litter samples using Tullgren-Berlese funnels. Most of specimens were cleared in lactic acid and mounted on slides in Hoyer's medium. The terminology of the idiosoma and legs follows that of Lindquist (1986); the nomenclature of subcapitular setae and the designation of cheliceral setae follow those of Grandjean (1944, 1947), respectively. The systematics of Pygmephoroidea follows that of Khaustov (2004, 2008). All measurements are given in micrometers (μm) for the holotype and paratypes (in parentheses). For leg chaetotaxy, the number of solenidia is given in parentheses. Mite morphology was studied using a Carl Zeiss AxioImager A2 compound microscope with phase contrast and differential-interference contrast (DIC) optics. Photomicrographs were taken with an AxioCam ICc5 (Carl Zeiss, Germany) digital camera. For SEM microscopy several alcohol-preserved mites were dried in a JFD 320 freeze drying device (JEOL, Japan), dusted with gold and scanned with a TESCAN Mira3 LMU SEM microscope.

Abbreviations: Ap1-5 – apodemes 1-5; appr – prosternal apodeme; apsej – sejugal apodeme; appo – poststernal apodeme; ags, pgs – anterior and posterior genital sclerites; php 1-3 – pharyngeal pumps; cl – palptibial claw; ς – eupathid-like seta on palptarsus; ZINRAN—Zoological Institute of Russian Academy of Sciences, St. Petersburg, Russia, TSUMZ—Tyumen State University, Museum of Zoology, Tyumen, Russia.

RESULTS

Systematics

Family Microdispidae Cross, 1965

Genus *Promicrodispus* Khaustov, 2017

Type species: *Brennandania pumilis* Sevastianov, 1975, by original designation

***Promicrodispus altaicus* Khaustov sp. nov.** (Figures 1-9)

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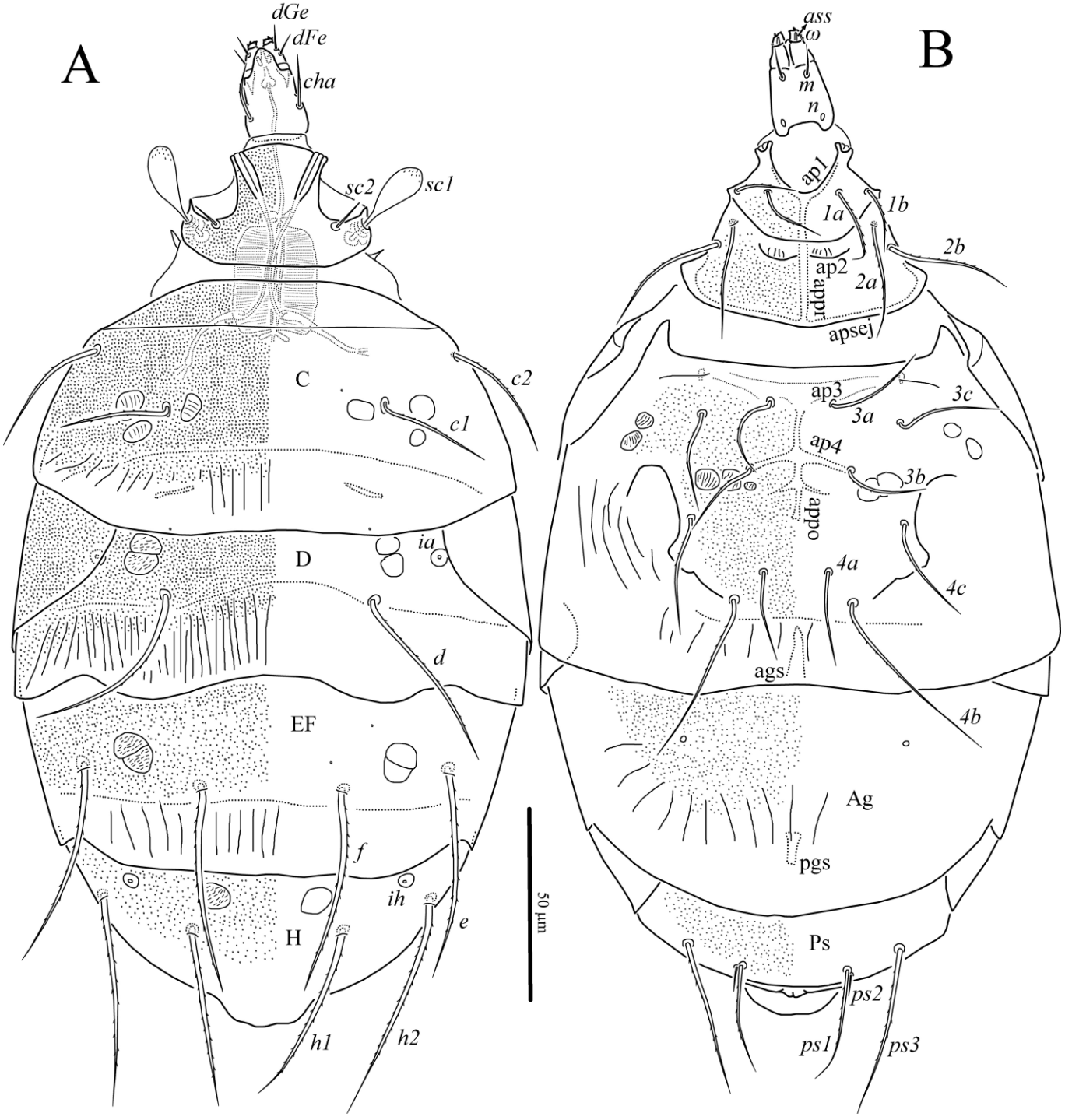

Figure 1. *Promicrodispus altaicus* Khaustov sp. nov., female: **A.** Dorsum of body; **B.** Venter of body. Legs omitted.

Description

Female (n=13). Length of idiosoma 225 (200–235), width of tergite C 135 (120–135).

Gnathosoma (Figs 7, 8). Length of gnathosoma 24 (22–24), width 16 (14–16). Dorsal median apodeme absent. Cheliceral setae *cha* 14 (13–15) weakly barbed, pointed. Postpalpal setae flattened and blunt-tipped (Fig. 8C), situated anterolaterally to setae *cha*. Setae *dFe* 6 (4–6) slightly shorter than *dGe* 7 (6–7), both smooth and pointed. Subcapitular setae *m* 12 (11–13) smooth and pointed. Palpal tibiotarsus ventrally with sausage-like accessory setigenous structure (*ass*) and tiny (about 0.5) solenidion *ω* (Fig. 7F); tibial claw well-developed; palpal tibiotarsus with short spiniform seta (probably *l″*) laterad tibial claw, short eupathid-like seta (*ς*) mesad tibial claw, and tiny projection probably of setal origin (?) posterolaterad *ς* (Fig. 7B). Pharyngeal pumps grouped together; pumps 1 and 3 small, bow-shaped; pump 2 large, subrectangular and transversely striated (Fig. 5D).

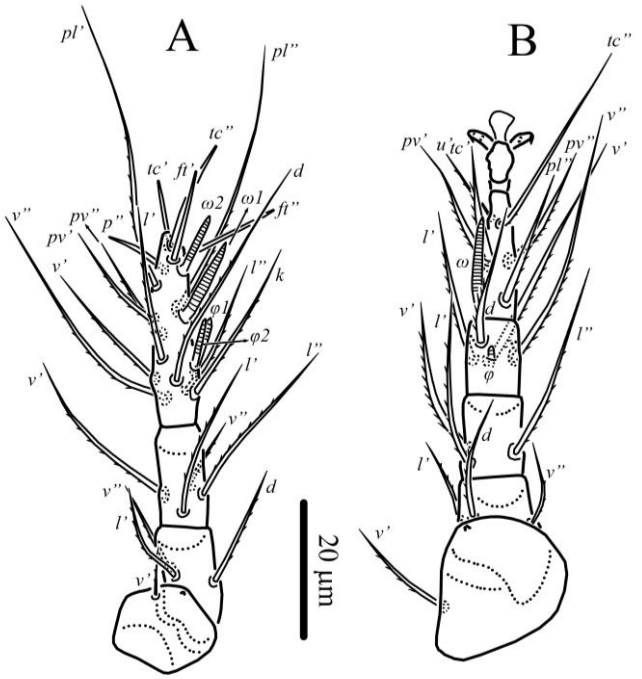

Figure 2. *Promicrodispus altaicus* Khaustov sp. nov., female: **A.** Right leg I, dorsal aspect; **B.** Right leg II, dorsal aspect.

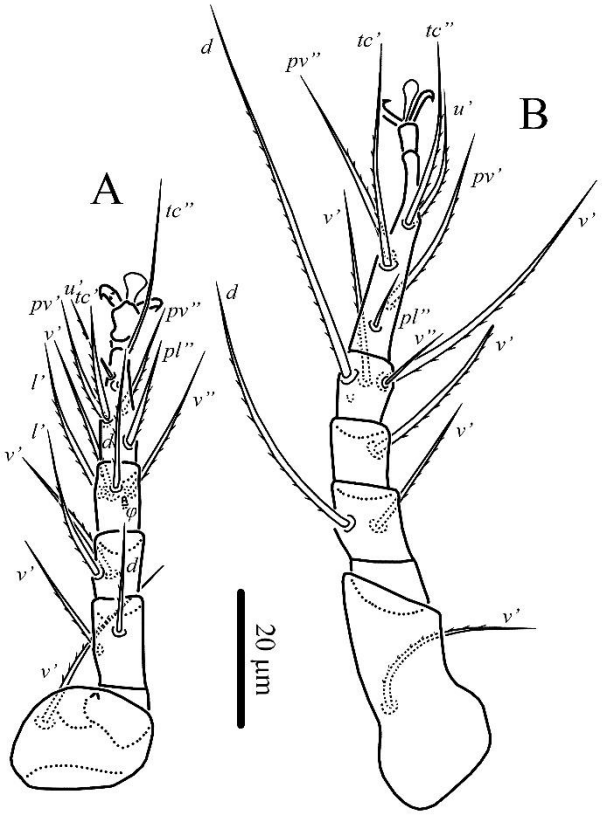

Figure 3. *Promicrodispus altaicus* Khaustov sp. nov., female: **A.** Right leg III, dorsal aspect; **B.** Right leg IV, dorsal aspect.

Idiosomal dorsum (Figs 1A, 4A, 5A-C, 6A, B). Prodorsum separated from tergite C in slide-mounted specimens (Fig. 5A) and covered by tergite C in alive mites (Fig. 6A). Prodorsum with one pair of elongate stigmata with longitudinal slit-like openings leading from dorsal side to ventral (Figs 5A, 7D) and one pair of lateral spines (Fig. 5A). Posterior margin of tergite H with short and wide lobe. All dorsal shields with numerous very small round puncta (Figs 5A-C). Setae sc_2 short, smooth, needle-like, other dorsal setae sparsely barbed and pointed. Trichobothria with short stem, clavate, sparsely barbed, with rounded apex (Fig. 6E). Cupules *ia* on tergite D and *ih* on tergite H large, round; *ia* situated anterolaterally to bases of setae *d*; *ih* situated anteromedially to bases of setae *h2*. Tergite C with two pairs of porous areas situated laterally to bases of *c1* and with one pair posteromedially to *c1*; tergite D with one pair of porous areas situated anterolaterally to setae *d*; tergite EF with oval porous areas situated medially to bases of setae *e*; tergite H with oval porous areas situated anteriorly to setae *h1*. Tergites C, D and EF with weak longitudinal striae posteriorly. Lengths of dorsal setae: *sc2* 9 (7–9), *c1* 29 (27–29), *c2* 37 (33–37), *d* 50 (48–52), *e* 57 (54–60), *f* 53 (47–54), *h1* 47 (45–47), *h2* 62 (58–64). Distances between setae: *sc2–sc2* 31 (29–31), *c1–c1* 56 (53–56), *c1–c2* 21 (18–21), *d–d* 53 (50–53), *e–f* – 30 (28–30), *f–f* 37 (33–37), *h1–h1* 38 (32–38), *h1–h2* 25 (24–26).

Idiosomal venter (Figs 1B, 4B, 5E, F, 6D, F, 7A-C). Ventral plates with numerous very small puncta (Figs 5E, F). All ventral setae pointed; setae *ps2* smooth; other ventral setae barbed; in some specimens setae *4a* smooth; setae *ps1* and *ps2* contiguous (Figs 5F, 6D). Lateral plates with several oblique sclerotized lines laterally to legs III–IV (Fig. 6C). Ap1, appr and apsej well sclerotized and fused together; ap2 very thin and fused with appr; appo and ap4 well sclerotized and fused; ap3 very weakly sclerotized and poorly visible (Fig. 5E); ap5 absent. Posterior sternal plate with two pairs of porous areas just laterad ap4 and with two pairs of porous areas anteriad legs III. Posterior margin of posterior sternal plate weakly concave. Posterior margin of aggenital plate evenly rounded. Lengths of ventral setae: *1a* 24 (24–25), *1b* 19 (16–19), *2a* 32 (28–32), *2b* 37 (32–38), *3a* 26 (26–30), *3b* 22 (20–24), *3c* 27 (23–28), *4a* 24 (24–26), *4b* 47 (46–48), *4c* 30 (28–31), *ps1* 29 (26–29), *ps2* 6 (5–6), *ps3* 44 (38–44).

Legs (Figs 2, 3, 9). Setation of legs as in generic diagnosis (Khaustov 2017) except absence of seta *s* on tibiotarsus. Leg I (Figs 2A, 9A-D). Lengths of solenidia *ω*1 13 (13), *ω2* 10 (9–10), *φ1* 8 (8–9), *φ2* 7 (6–7); *φ1* weakly clavate, *ω1* digitiform with attenuate tip, *ω2* and *φ2* baculiform. All setae of leg I (except eupathidia (*tc*), (*ft*) and *p"*) sparsely barbed and pointed. Leg II (Fig. 2B). Solenidion *ω* 14 (12–1) digitiform with attenuate tip, solenidion *φ* 4 (3–4) rod-like, situated in shallow depression. All setae on leg segments pointed and sparsely barbed; seta *tc"* usually with only several weak barbs in basal part. Leg III (Fig. 3A). Solenidion *φ* 2 (2) very short, situated in depression and hardly visible. All setae on leg segments pointed and sparsely barbed; seta *tc"* usually with only several weak barbs in basal part. Leg IV (Fig. 3B). Solenidion *φ* absent, but tibia with small pore-like depression instead of solenidion. Setae *v"* of tibia and *pl"* of tarsus smooth, other setae on leg segments sparsely barbed; seta *v"* of genu blunt-tipped, other leg setae pointed.

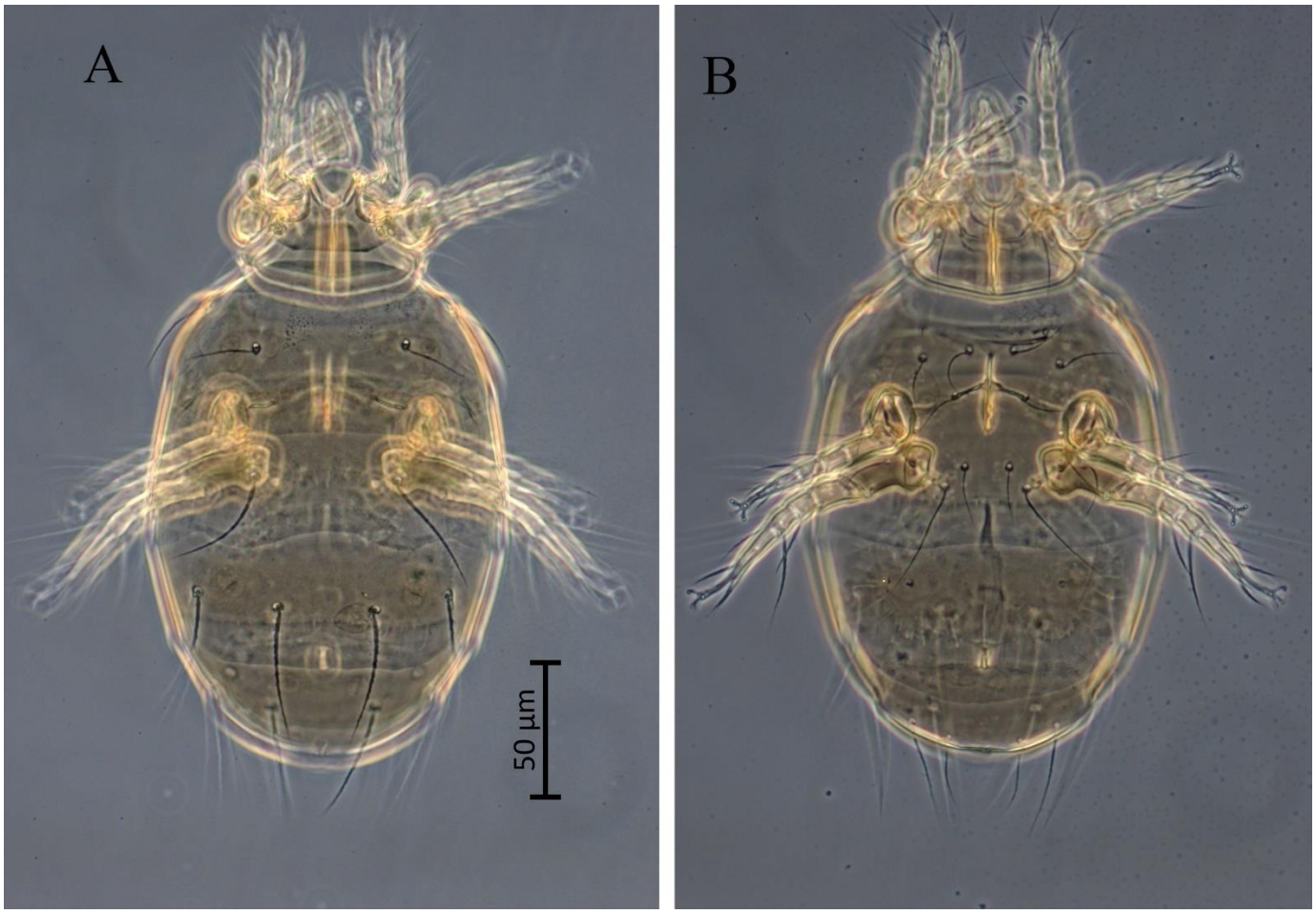

Figure 4. Phase-contrast micrographs of *Promicrodispus altaicus* Khaustov sp. nov., female (holotype): **A.** General view dorsally; **B.** General view ventrally.

Male and larva unknown.

Type material. Holotype female, slide ZISP T-Mcd-4, Russia, Altai Republic, Turochaksky District, vicinity of Teletskoye Lake, bank of Tebenek River, 453 m a.s.l., 01 October 2023, in forest litter, 51°47'28.914" N 87°19'15.132" E, coll. A. O. Svinin; paratypes: 12 females, same data.

Type deposition. The holotype and one paratype female are deposited in the collection of ZINRAN; other paratypes are deposited in the collection of the TSUMZ.

Differential diagnosis. The new species is closely resembles to *P. pumilis* in having very similar relative lengths of idiosomal setae and presence of one pair of cheliceral setae. The new species differs from *P. pumilis* in having setae *ps2* (vs. setae *ps2* absent in *P. pumilis*) and in absence of seta *s* on tibiotarsus of leg I (vs. present in *P. pumilis*).

Etymology. The name of the new species *altaicus* refers to its geographical distribution in Altai Mountains.

Key to species of the genus *Promicrodispulus* (females)

1a. Gnathosoma dorsally with one pair of setae (*cha*) …… 3

1b. Gnathosoma dorsally with two pairs of setae (*cha*, *chb*) …… 2

2a. Setae *ps2* absent; three solenidia on tibiotarsus I …… *P. bisetus*

2b. Setae *ps2* present; four solenidia on tibiotarsus I …… *P. salinus*

3a. Setae *ps2* absent; seta s of tibiotarsus I present …….. 4

3b. Setae *ps2* present; seta s of tibiotarsus I absent …….. *P. altaicus* Khaustov sp. nov.

4a. Setae *d* and *f* subequal in length …….. *P. pumilis*

4b. Setae *d* distinctly longer than *f* …….. *P. fageus*

DISCUSSION

Using of scanning electron microscope for the study of the external morphology of *Promicrodispus altaicus* Khaustov sp. nov. revealed several structures of gnathosoma previously unknown in Microdispidae. The most expected is the presence of palpal solenidion *ω*. This solenidion is usually present in other pygmephoroid mites (Pygmephoridae, Neopygmephoridae, Scutacaridae) as well as in other early derivative Heterostigmata (Lindquist, 1986; Dastych and Rack, 1993). In *P. altaicus* Khaustov sp. nov. palpal solenidion is very small (about 0.5) and almost invisible in the light microscope. Despite some SEM photos of the gnathosoma in several representatives of Microdispidae (Khaustov, 2014; Khaustov et al., 2019) it has never been

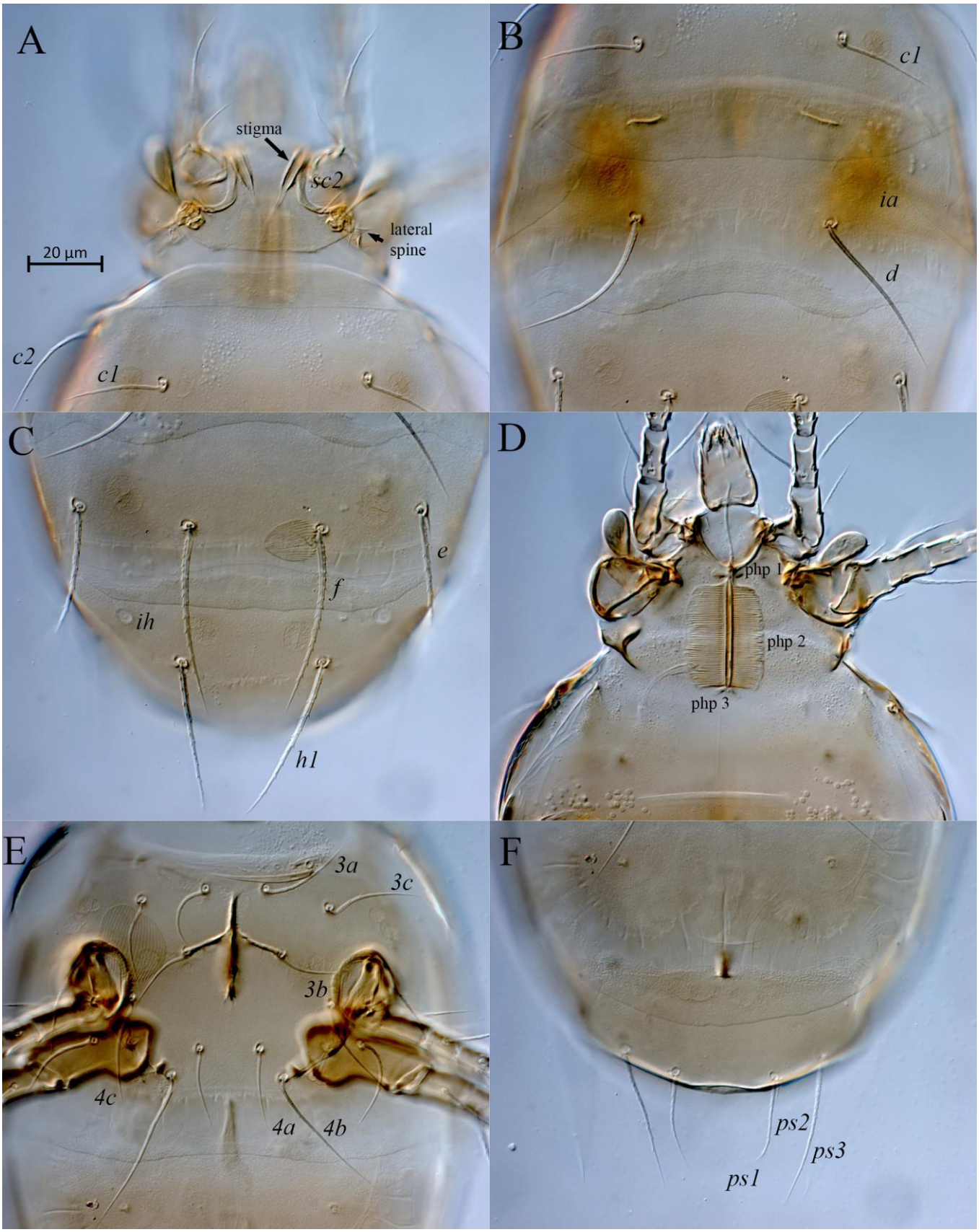

Figure 5. DIC micrographs of *Promicrodispus altaicus* Khaustov sp. nov., female (holotype): **A.** Proterosoma, dorsal aspect; **B.** Metapodosoma, dorsal aspect; **C**. Opisthosoma, dorsal aspect; **D**. Pharyngeal pumps; **E**. Metapodosoma, ventral aspect; **F.** Opisthosoma, ventral aspect.

found. Other unexpected structures are spiniform seta (probably *l''*) laterad tibial claw and tiny structure (probably of setal origin) mesad tibial claw and indicated by "?" in Figure 8B.

Seta *l''* of palpal tibiotarsus has never been reported in Pygmephoroidea. However, it was found in early derivative Tarsonemina, such as Dolichocybidae (Khaustov and Trach, 2018) and Athyreacaridae (Khaustov and Frolov,

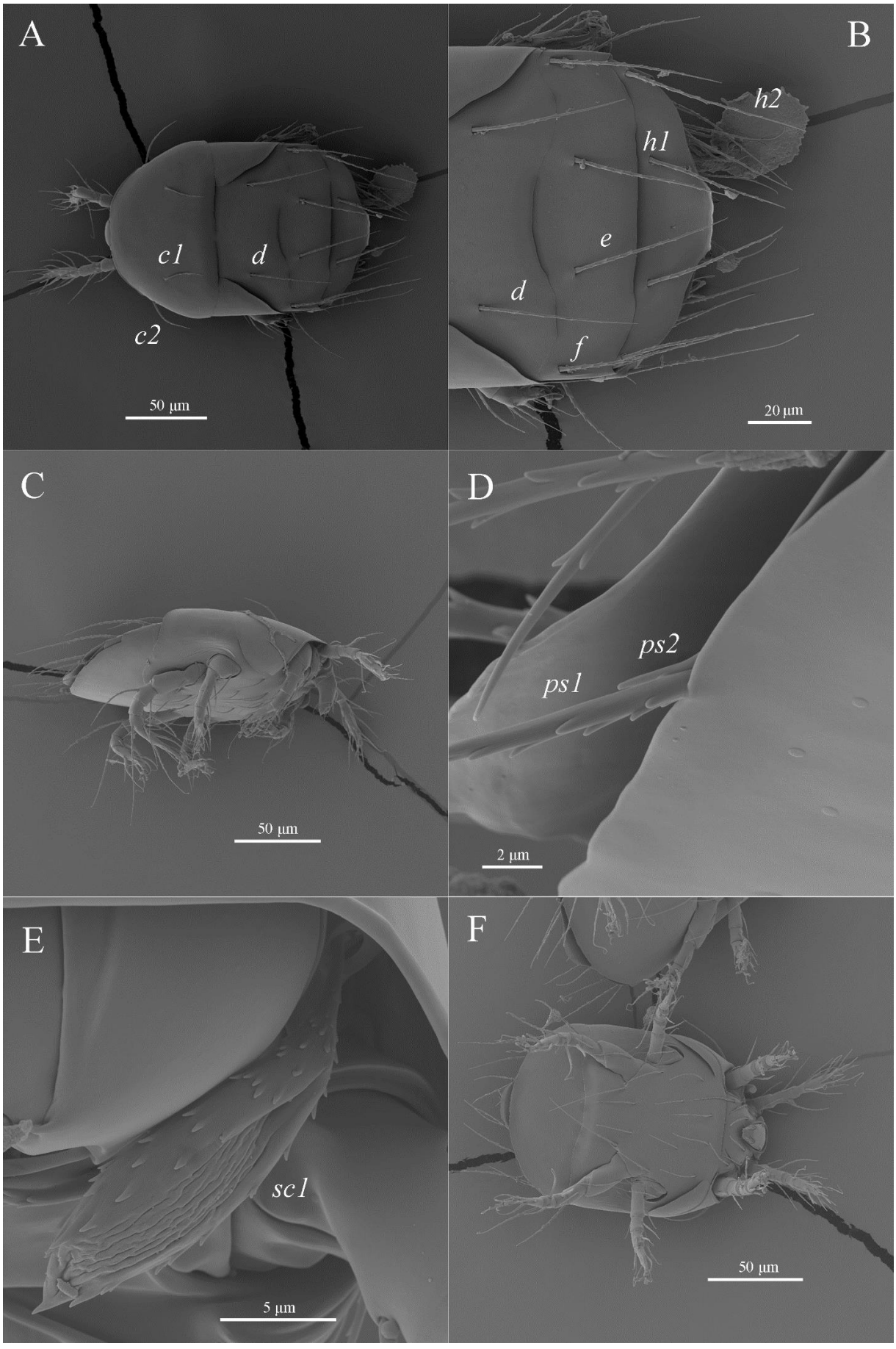

Figure 6. SEM micrographs of *Promicrodispus altaicus* Khaustov sp. nov., female: **A**. General view dorsally; **B**. Hysterosoma, dorsal aspect; **C**. General view laterally; **D.** Pseudanal setae *ps1* and *ps2*; **E**. Trichobothrium; **F**. General view ventrally.

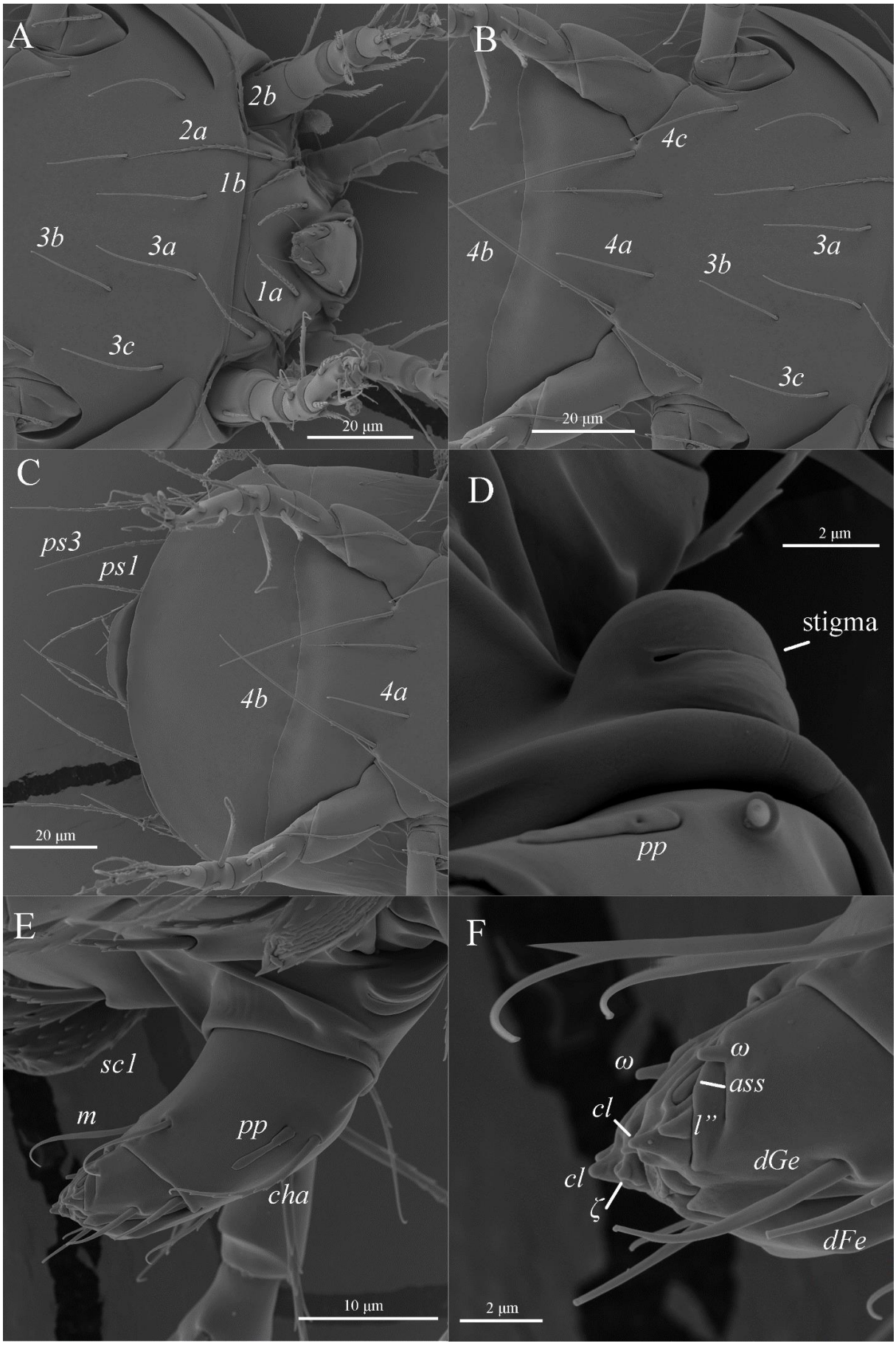

Figure 7. SEM micrographs of *Promicrodispus altaicus* Khaustov sp. nov., female: **A.** Proterosoma, ventral aspect; **B**. Metapodosoma, ventral aspect; **C**. Opisthosoma, ventral aspect; **D.** Stigma; **E**. Gnathosoma, lateral aspect; **F**. Distal part of gnathosoma, lateral aspect.

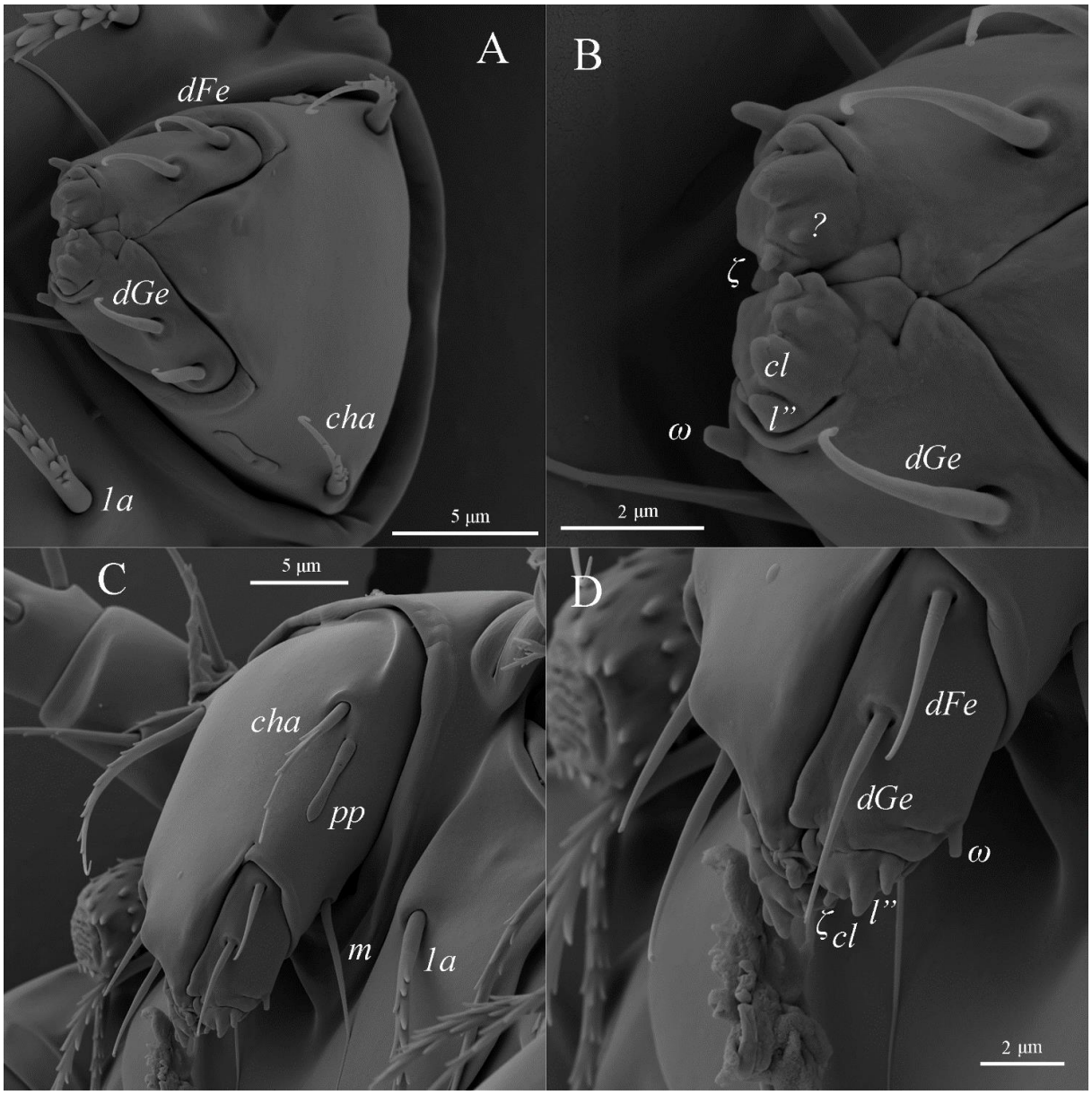

Figure 8. SEM micrographs of *Promicrodispus altaicus* Khaustov sp. nov., female: **A**. General view of gnathosoma, dorsal aspect; **B**. Distal part of gnathosoma, dorsal aspect; **C**. Gnathosoma, doesolateral aspect; **D**. Distal part of gnathosoma, dorsolateral aspect.

2022). The tiny structure (?) located posteriad eupathid-like seta is probably was discovered in *Pygmephorus* species (Pygmephoridae) and indicated by arrow in Figure 4 in Dastych and Rack (1993). This seta of unknown homology was also reported in *Bembidiacarus* (Khaustov, 2000). Based on the present study, the gnathosoma of *P. altaicus* Khaustov sp. nov. includes almost the full set of setiform gnathosomal structures (except absence of setae *chb*) and represents plesiomorphic character states in Microdispidae.

Authors' contributions

Alexander A. Khaustov: Identification of mite species, preparation of the manuscript, line drawings and light microscope photos. **Nikita A. Shulaev:** Preparation of samples for electron microscopy, preparation of SEM images, manuscript reviewing.

Statement of ethics approval

Not applicable.

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Conflict of interest

The authors declared that there is no conflict of interest.

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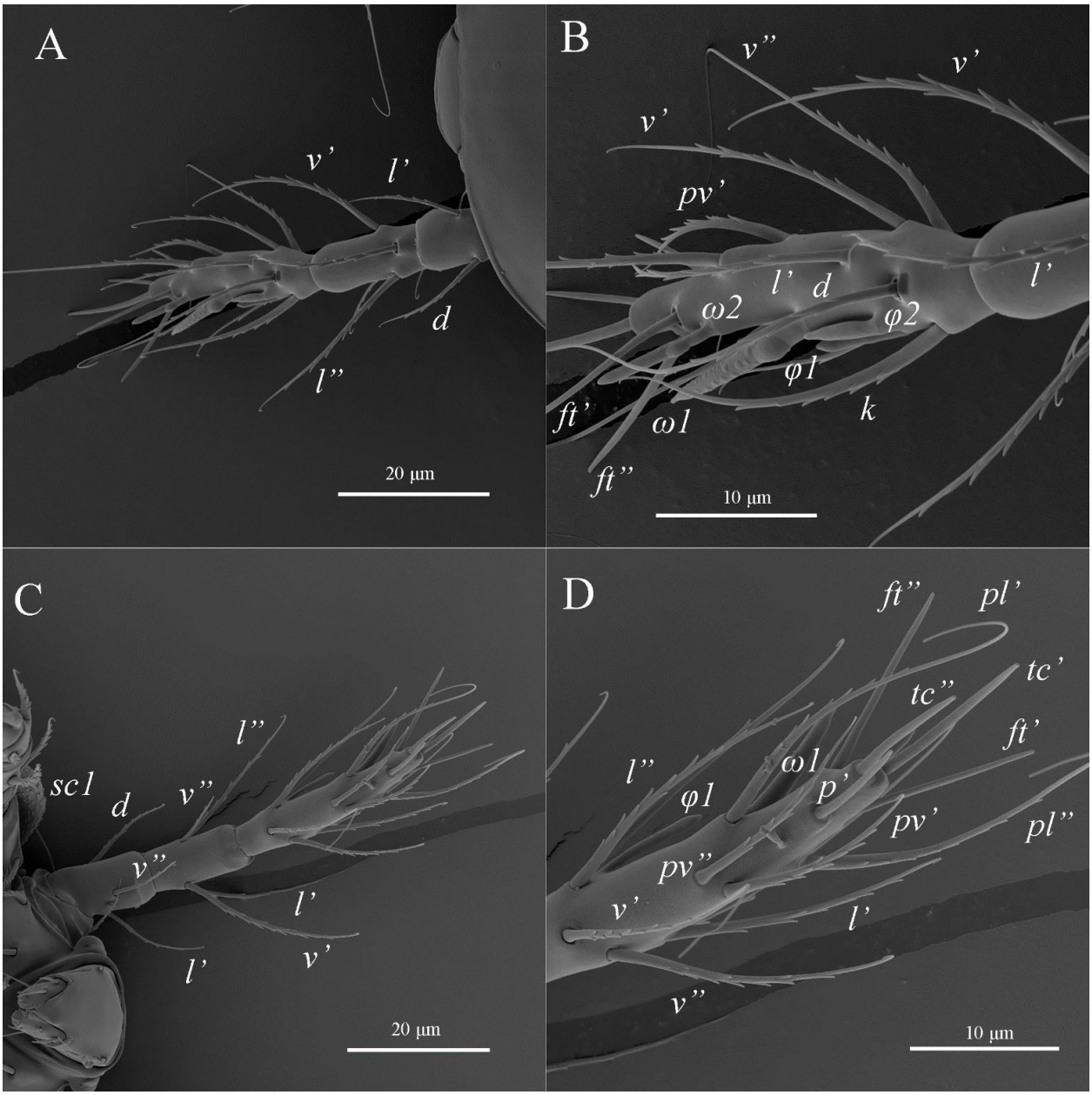

Figure 9. SEM micrographs of *Promicrodispus altaicus* Khaustov sp. nov., female: **A**. Leg I, dorsal aspect; **B**. Tibiotarsus I, dorsal aspect; **C**. Leg I, ventral aspect; **D**. Tibiotarsus I, ventral aspect.

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RESEARCH ARTICLE

Complementary description of *Neoseiulus neoparaki* (Ehara) (Parasitiformes: Phytoseiidae), a new record for Sakhalin Island, Russia

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ABSTRACT: *Neoseiulus neoparaki* (Ehara) (Parasitiformes: Phytoseiidae) was described about 50 years ago and known only based on its original description from Japan. The original description is quite detailed and include most of diagnostic characters, but still not complete since it lacks the chelicera dentition and some important morphological features regarding leg chaetotaxy. Therefore, this species is redescribed and illustrated based on the material collected from Kuril bamboo, *S. kurilensis* in Sakhalin Island, Russia. This is the first discovery of *N. neoparaki* after its original description, and therefore the first report for Russia.

Keywords: Acari, first record, redescription, predatory mites, leg chaetotaxy
Zoobank: https://zoobank.org/8ABC4658-5B22-4744-AC82-2F21E1744486

INTRODUCTION

Phytoseiidae are among the most studied families within Parasitiformes mites due to their potential as biological control agents (McMurtry et al., 2013). The genus *Neoseiulus* Hughes is one of the largest in the family Phytoseiidae, with about 400 described species including synonyms (Demite et al., 2014). The genus includes some important Type II selective predators of tetranychid mites such as *N. californicus* (McGregor), *N. fallacis* (Garman), and *N. longispinosus* (Evans) but also Type III generalist predators found in soil/litter habitats, such as *N. barkeri* Hughes and *N. cucumeris* (Oudemans) (McMurtry et al., 2013). Therefore, *Neoseiulus* species has great potential to be used for the biological control of plant-feeding mites and some small soft-bodied insects that include thrips and whiteflies.

Neoseiulus neoparaki (Ehara, 1972) (Phytoseiidae) was known only from its original description which was based on the holotype female and the paratype male collected from Kuril bamboo, *Sasa kurilensis* (Rupr.) Makino & Shibata (Poaceae) in Shiga Heights, Nagano Prefecture, Honshu, Japan. Although the original description is quite detailed, it does not include several important morphological characters regarding the chelicera dentition and leg chaetotaxy. These two features are frequently used to delimitate *Neoseiulus* species (Zannou et al., 2006; Ferragut and Navia, 2017; Doker et al., 2023). Therefore, in this study, *N. neoparaki* is redescribed and illustrated based on adult females.

MATERIALS AND METHODS

Female specimens were collected from Kuril bamboo, *Sasa kurilensis* (Rupr.) Makino & Shibata (Poaceae) plants in 2021 in Sakhalin Island, Russia. The beating method was used to collect the specimens. For this aim, a thick and a black paper sheet (40 X 50 cm in size) were placed next to the plant's vegetative organs, and the plant was beaten 15-20 times by using a 50 cm wood stick. The phytoseiids on the plants were fallen on the black sheet and were easily recognized due to their fast movement and color. The phytoseiids were then transferred and preserved in plastic tubes which contained 96% ethyl alcohol. Specimens were cleared in lactic acid and mounted in Hoyer's medium. The taxonomic system proposed by Chant and McMurtry (2007) for the Phytoseiidae family is followed. Setal nomenclature for the dorsal idiosoma follows that of Lindquist and Evans (1965) as adapted by Rowell et al. (1978), and Chant and Yoshida-Shaul (1991). For the designation of dorsal solenostomes, the system of Athias-Henriot (1975) is used. Measurements are given in micrometers (µm) and presented as mean followed by the range in brackets. Morphological observations, illustrations and measurements were made using a compound microscope Axio Imager A2 (Carl Zeiss, Germany), equipped with a differential interference contrast (DIC) optical system. Photographs were taken with Axiocam 506 color (Carl Zeiss, Germany). Dorsal shield length was measured along the midline. The examined materials are deposited in Tyumen State University Museum of Zoology, Tyumen, Russia. Two females are deposited in the mite collection of the Acarology Laboratory, Çukurova University, Adana, Türkiye.

RESULTS

Neoseiulus neoparaki (Ehara)

Amblyseius (*Amblyseius*) *neoparaki* Ehara, 1972: 153.

Diagnosis

Idiosomal setal pattern 10A:9B/*JV*–3: *ZV* (*r3* and *R1* off shield). Dorsal shield sclerotized, mostly smooth, except lateral reticulations and a few posterior striations; with slight waist at level of *Z1*; with six pairs of solenostomes

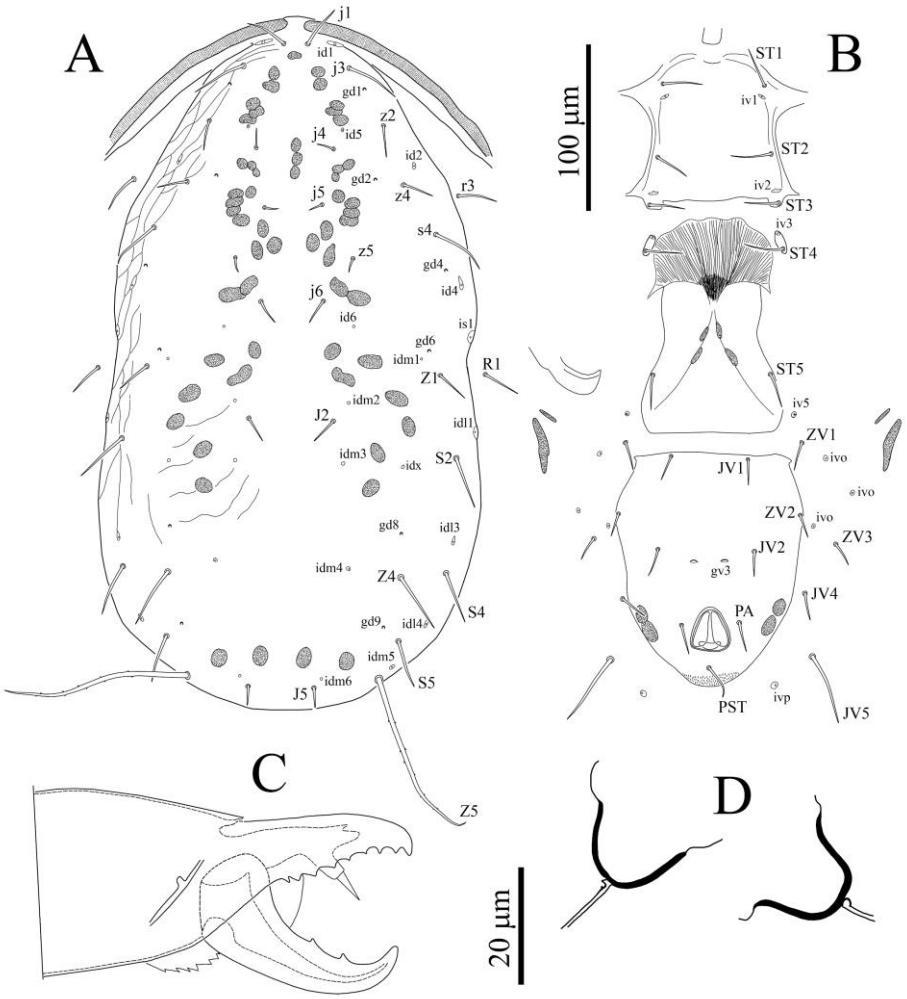

Figure 1. *Neoseiulus neoparaki* (Ehara) (female): **A.** Dorsal idiosoma, **B.** Ventral idiosoma, **C.** Chelicera, **D.** Spermathecae.

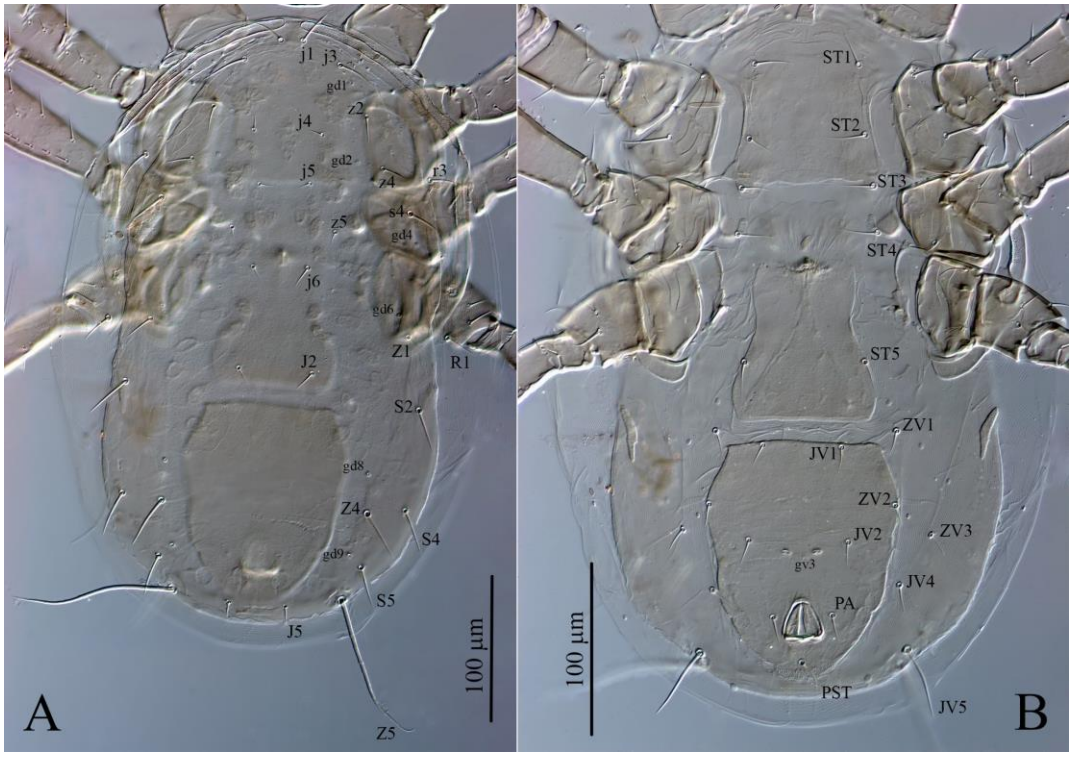

Figure 2. DIC micrographs of *Neoseiulus neoparaki* (Ehara) (female): **A.** Dorsal idiosoma, **B.** Ventral idiosoma.

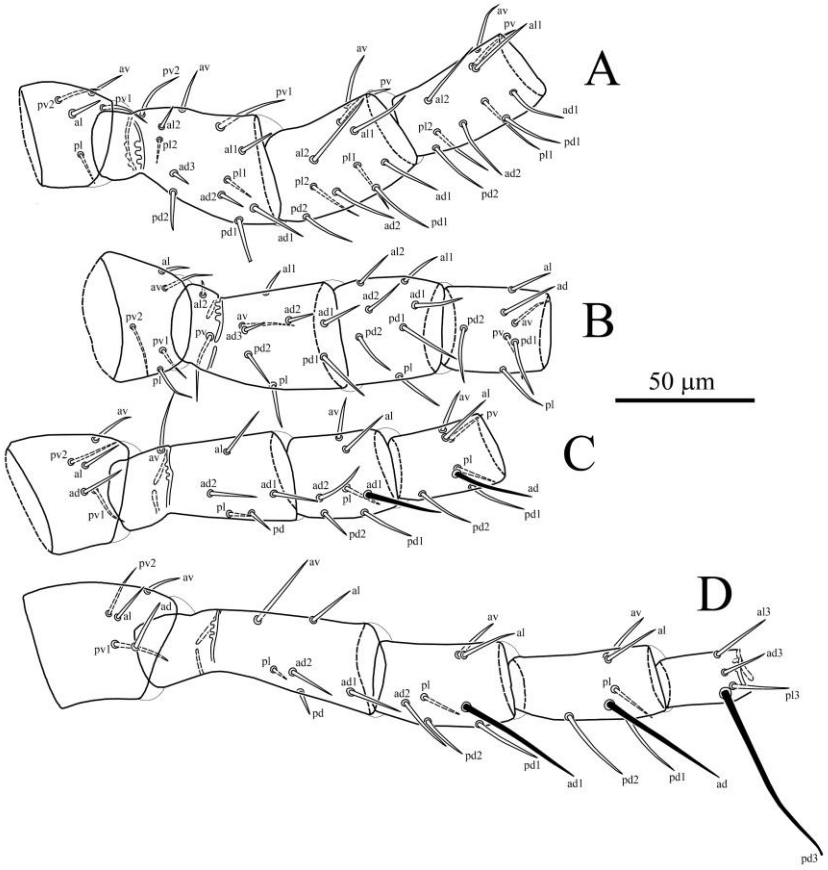

Figure 3. *Neoseiulus neoparaki* (Ehara), right legs of female: **A.** Leg I (coxa and tarsus omitted), **B.** Leg II (coxa and tarsus omitted), **C.** Leg III (coxa and tarsus omitted), **D.** Leg IV (coxa and telotarsus omitted). Macrosetae were drawn in solid black for clarity.

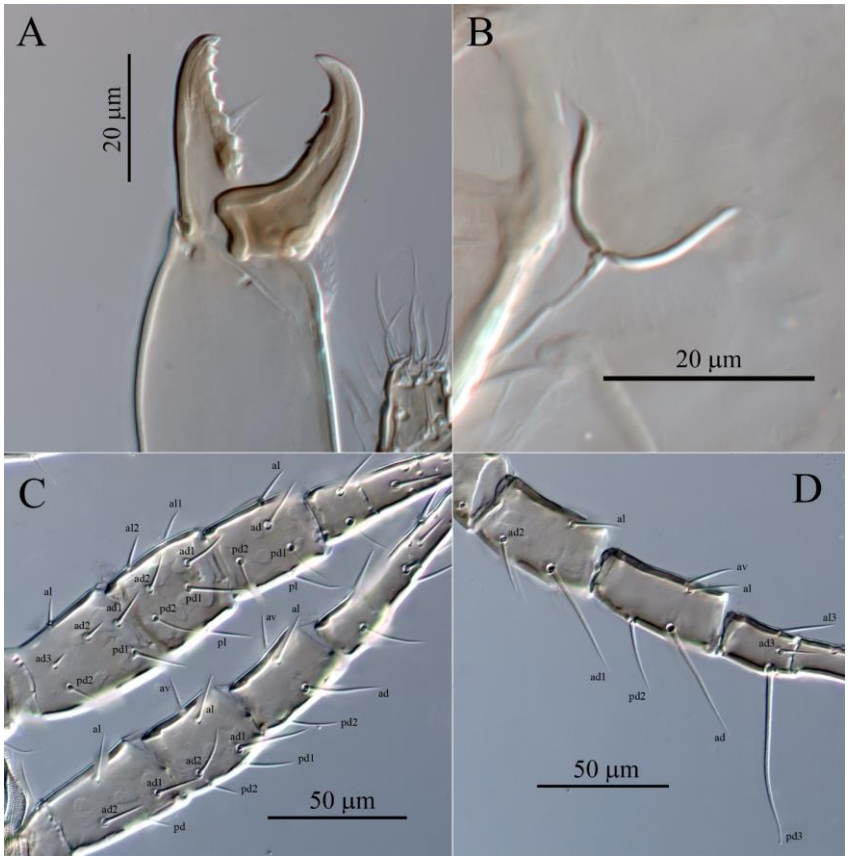

Figure 4. *Neoseiulus neoparaki* (Ehara) (female): **A.** Chelicera, **B.** Spermatheca, **C.** Leg II, dorsal view (femur-basitarsus) and leg III, dorsal view (genu-basitarsus), **D.** Leg IV (genu, tibia and basitarsus).

(*gd1*, *gd2*, *gd4*, *gd6*, *gd8*, and *gd9*); dorsal setae simple, short to medium in length, except *Z5* serrated and more than 2.5 times longer than other setae. Peritremes extending anteriorly to seta *j1*. All ventral shields smooth; sternal shield with three pairs of setae; ventrianal shield pentagonal with three pairs of preanal setae and a pair of crescentic preanal solenostomes located posteromesad setae *JV2*; seta *JV5* smooth and sharp pointed. Spermatheca with short, cup-shaped calyx and small nodular atrium attached to calyx without neck. Fixed digit of chelicera with eight teeth, evenly distributed along digit, and movable digit with two teeth. First two legs without macroseta. Leg III with two and Leg IV with three macrosetae. Macrosetae sharp pointed except *StIV* with very small apical knob. Genu II with seven setae.

Re-description: Female (n=5).

Dorsal idiosoma (Figs 1A, 2A). Dorsal setal pattern 10A: 9B (*r3* and *R1* off shield). Dorsal shield mostly smooth, except lateral reticulations and a few posterior striations, with slight waist at level of seta *Z1*, with six pairs of solenostomes (*gd1*, *gd2*, *gd4*, *gd6*, *gd8* and *gd9*), and 16 pairs of poroids (sensillae) (*id1*, *id2*, *id4*, *id5*, *id6*, *idm1*, *idm2*, *idm3*, *idm4*, *idm5*, *idm6*, *idx*, *is1*, *idl1*, *idl3* and *idl4*). Muscle-marks (sigillae) visible mostly on podosoma, length of dorsal shield 413 (399–422), width (at level of *s4*) 206 (198–218), width (at level of *S2*) 222 (211–230). Dorsal setae smooth except *Z5*, serrated. Measurements of dorsal setae as follows: *j1* 22 (21–24), *j3* 32 (31–35), *j4* 11 (10–13), *j5* 9 (8–10), *j6* 17 (16–17), *J2* 17 (16–19), *J5* 12 (11–13), *z2* 17 (16–18), *z4* 17 (15–18), *z5* 9 (8–10), *Z1* 19 (17–20), *Z4* 36 (35–38), *Z5* 105 (101–110), *s4* 35 (34–36), *S2* 31 (28–32), *S4* 30 (27–32), *S5* 28 (26–29), *r3* 24 (23–25), and *R1* 23 (22–24). Peritremes extend anteriorly to setae *j1*.

Ventral idiosoma (Figs 1B, 2B). Ventral setal pattern 14: *JV–3*: *ZV*. Sternal shield smooth; with three pairs of setae (*ST1–ST3*) and two pair of poroids (*iv1*, *iv2*); distance between bases of setae *ST1–ST3* 73 (72–75), distance between bases of setae *ST2* 67 (66–68); metasternal setae *ST4* and poroids *iv3* on metasternal shields. Genital shield smooth, slightly narrower than ventrianal shield, with one pair of setae *ST5*; width (at level of *ST5*) 71 (70–72); one pair of para-genital poroids *iv5* on soft cuticle. Ventrianal shield pentagonal, smooth; with three pairs of pre-anal setae (*JV1*, *JV2*, and *ZV2*), one pair of para-anal setae *PA*, unpaired post-anal seta *PST*, and a pair of crescentic solenostomes (*gv3*) posteromedian to *JV2*, distance between solenostomes 20 (18–24). Length of ventrianal shield (distance between anterior to posterior margins along midline) 143 (137–146), width (at level of *ZV2*) 111 (105–115). Four pairs of caudoventral setae (*ZV1*, *ZV3*, *JV4*, and *JV5*) and four pairs of poroids (three *ivo*, and *ivp*) on soft cuticle surrounding ventrianal shield. Setae *JV5* smooth, 45 (43–50) in length.

Chelicera (Figs 1C, 4A). Fixed digit 33 (31–37) long, with eight teeth evenly distributed along digit and pilus dentilis; movable digit 35 (34–37) long, with two teeth.

Spermatheca (Figs 1D, 4B). Calyx short, cup-shaped, 12 (11–12) long, atrium nodular connected to calyx without neck, major duct narrow, minor duct not visible.

Legs (Figs 3A-D, 4C-D). Leg I 330 (321–342), II 278 (272–283), III 290 (277–305), IV 373 (361–389) in length. Chaetotaxy of legs as follows: Leg I: coxa 0 0/1 0/1 0, trochanter 1 0/1 0/2 1, femur 2 3/1 2/2 2, genu 2 2/1 2/1 2, tibia 2 2/1 2/1 2. Leg II: coxa 0 0/1 0/1 0, trochanter 1 0/1 0/2 1, femur 2 3/1 2/1 1, genu 2 2/0 2/0 1, tibia 1 1/1 2/1 1. Leg III: coxa 0 0/1 0/1 0, trochanter 1 1/1 0/2 0, femur 1 2/1 1/0 1, genu 1 2/1 2/0 1, tibia 1 1/1 2/1 1. Leg IV: coxa 0 0/1 0/0 0, trochanter 1 1/1 0/2 0, femur 1 2/1 1/0 1, genu 1 2/1 2/0 1, tibia 1 1/1 2/0 1. First two legs without macroseta. Leg III with two and Leg IV with three macrosetae. Macrosetae sharp pointed except *StIV* with very small apical knob. Measurements of macrosetae as follows: *SgeIII* (*ad1*) 26 (25–28), *StiIII* (*ad*) 27 (25–28), *SgeIV* (*ad1*) 43 (41–46), *StiIV* (*ad*) 46 (44–47), and *StIV* (*pd3*) 63 (59–67).

Male. Not collected in this study.

Material examined. Five females from Kuril bamboo, *Sasa kurilensis* (Rupr.) Makino & Shibata (Poaceae) in Sakhalin Island, Chekhov Mountain, Yuzhno-Sakhalinsk, Russia, 46° 59' 23" N, 142° 50' 07" E, 842 meters above sea level, 13 August 2021, collected by Khaustov V.A., Döker İ., Joharchi O., and Khaustov A.A.

DISCUSSION

Neoseiulus neoparaki was described based on the material collected from Kuril bamboo, *S. kurilensis* in Shiga Heights, Nagano Prefecture, Honshu, Japan. The original description is quite detailed and includes most of the diagnostic characters. However, the chelicera dentition and macrosetae on leg III were not mentioned in that original description. This is the first discovery of the species after its original description, and therefore the first report for Russia. Morphological characters and measurements of the newly collected material are almost identical to those given by Ehara (1972).

Authors' contributions

Vladimir A. Khaustov: Material collection, identification of mite species, investigation, visualization, review-editing. **İsmail Döker:** Material collection, identification of mite species, investigation, writing original draft, review-editing. **Omid Joharchi:** Material collection, investigation, review-editing.

Statement of ethics approval

Not applicable.

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Conflict of interest

The authors declared that there is no conflict of interest.

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RESEARCH ARTICLE

Contributions to the knowledge of the water mite fauna (Acariformes, Hydrachnidia) of Türkiye with descriptions of two new species

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ABSTRACT: In this study, water mites have been collected from running waters and springs in Elazığ province (Eastern Türkiye). Totally, twenty species are identified. The families, Hydrovolziidae and Feltriidae are newly recorded from Elazığ province. *Atractides* (*Atractides*) *ermani* sp. nov. and *A.* (*Atractides*) *elazigensis* sp. nov. are described as new to science. Additionally, the recent list of known number of species of water mite in Türkiye by provinces is given based on published data with an overall assessment.

Keywords: Acari, *Atractides*, diversity, Elazığ, species number
Zoobank: https://zoobank.org/43C6F2B5-F663-4E2C-9C61-22FDF5227933

INTRODUCTION

Türkiye is very rich in terms of biodiversity, but the knowledge on the water mite fauna of Türkiye is still lacking. To date, 25 families, 62 genera and 336 species of water mites are known from Türkiye (Erman et al., 2010, 2019; Esen, 2021). Research on water mites has been continuing rapidly based on materials collected from different provinces in Türkiye for the last twenty years.

The first list of the water mite fauna of Elazığ province was given by Erman and Özkan (2000) with 51 species in 15 families. Later on, studies on water mite fauna of Elazığ province continued by Pešić et al. (2006), Pešić and Erman (2006), Erman et al. (2006, 2008), Esen and Erman (2018). Including the present study, the total number of the water mites' taxa recorded from Elazığ reaches to 76 species in 17 families.

During a survey on the freshwater fauna of Türkiye, several species of the mite were collected from Elazığ province, including two undescribed species. The aim of this work is to contribute to the water mite diversity of Türkiye, to describe two new species and give the recent list of the numbers of species according to the provinces.

MATERIALS AND METHODS

The water mites were collected by hand netting, sorted on the spot from the living material, conserved in Koenike's fluid and dissected as described elsewhere (e.g., Gerecke et al., 2007). The holotype and paratypes of the new species are deposited in the research collection of the Department of Biology, Bingöl University, Bingöl, Türkiye. The composition of the material is given as: (males/females/deutonymphs). All measurements and scale bars in the figures are given in micrometres. For a detailed description and discussion of the characteristics of the genus *Atractides* and a detailed methodological introduction, see Gerecke (2003) and Davids et al. (2005).

The following abbreviations are used: a.s.l. = above sea level, Ac-1 = first acetabulum, Cx-I = first coxae, dL = dorsal length, H = height, HA = height on the level of ventral seta of I-L-5, HB = height on the level of ventrodistal edge of I-L-5, L = length, %L = relative length, I-L-6 = Leg 1, sixth segment (tarsus), mL = medial length, P-1 = palp, first segment, S-1 = large proximal ventral seta at I-L-5, S-2 = large distal ventral seta at I-L-5, Vgl = ventroglandulare, V = ventrale, W = width.

RESULTS

Family: HYDROVOLZIIDAE Thor, 1905

Genus: *Hydrovolzia* Thor, 1905

Hydrovolzia cancellata Walter, 1906

Material examined: Elazığ province, Arıcak district, Akdağlar mountain, low order streams, 38°37'56"N 40°08'00"E 2145 m a.s.l., 05.07.2018, (1/3/0).

Records from Türkiye: Afyon, Muş and Rize provinces (Erman et al., 2010).

Family: HYDRYPHANTIDAE Piersig, 1896

Genus: *Thyopsis* Piersig, 1899

Thyopsis cancellata (Protz, 1896)

Material examined: Elazığ province, Sivrice district, Sürek village, spring, 38°27'05" N, 39°21'49" E, 1290 m a.s.l., 13.07.2013, (1/0/0).

Records from Türkiye: Erzurum (Erman et al., 2010) and Malatya (Esen and Erman, 2012).

Genus: *Panisus* Koenike, 1896

Panisus torrenticolus Piersig, 1898

Materials examined: Elazığ province, Arıcak district, Akdağlar Mountain, low order streams, 38°37'56" N, 40°08'00" E, 2145 m a.s.l., 05.07.2018, (0/1/1).

Records from Türkiye: Afyon, Erzurum (Erman et al., 2010), Antalya (Boyacı et al., 2012) and Isparta (Durucan and Boyacı, 2020).

Genus: *Protzia* Piersig, 1896

Protzia rotunda Walter, 1908

Materials examined: Elazığ province, Sivrice district, Sürek village, spring, 38°27'05" N, 39°21'49" E, 1290 m a.s.l., 13.07.2013, (2/3/0).

Records from Türkiye: Afyon (Erman et al., 2010), Malatya (Esen and Erman, 2012) and Bingöl (Esen and Erman, 2013).

Family: SPERCHONTIDAE Thor, 1900

Genus: *Sperchon* Kramer, 1877

Sperchon (*Hispidosperchon*) *beckeri* Bader and Sepasgozarian, 1984

Materials examined: Elazığ province, Arıcak district, Akdağlar Mountain, low order streams, 38°37'56" N, 40°08'00" E, 2145 m a.s.l., 05.07.2018, (3/8/1).

Records from Türkiye: Elazığ (Esen, 2021).

Sperchon (*Hispidosperchon*) *clupeifer* Piersig, 1896

Material examined: Elazığ province, Arıcak district, Akdağlar Mountain, low order streams, 38°37'56" N, 40°08'00" E, 2145 m a.s.l., 05.07.2018, (0/1/0).

Records from Türkiye: Kayseri, Rize, Afyon, Erzurum, Malatya, Bingöl (Erman et al., 2010), Antalya (Boyacı et al., 2012), Erzincan (Esen et al., 2013), Siirt (Esen and Erman, 2015), Adıyaman (Beyaz et al., 2016) and Isparta (Durucan and Boyacı, 2020).

Genus: *Sperchonopsis* Piersig, 1896

Sperchonopsis verrucosa (Protz, 1896)

Materials examined: Elazığ province, Arıcak district, Akdağlar Mountain, low order streams, 38°37'56" N, 40°08'00" E, 2145 m a.s.l., 05.07.2018, (0/2/0).

Records from Türkiye: Afyon**,** Erzurum, Muş, Rize (Erman et al., 2010), Malatya (Esen and Erman, 2012), Antalya (Boyacı et al., 2012), Erzincan (Esen et al., 2013), Bingöl (Esen and Erman, 2013), Siirt (Esen and Erman, 2015), Burdur (Gülle et al., 2017) and Isparta (Durucan and Boyacı, 2020).

Family: ANISITSIELLIDAE Koenike, 1910

Genus: *Nilotonia* Thor, 1905

Nilotonia (*Manotonia*) *tegulata* (Viets, 1951)

Material examined: Elazığ Province, Sivrice district, Sürek village, spring, 38°27'05" N, 39°21'49" E, 1290 m a.s.l., 13.07.2013, (0/1/0).

Records from Türkiye: Isparta (Boyacı and Özkan, 2008; Durucan and Boyacı, 2020), Antalya (Boyacı et al., 2012), Erzincan (Esen et al., 2013) and Bingöl (Esen and Erman, 2013).

Family: LEBERTIIDAE Thor, 1900

Genus: *Lebertia* Neuman, 1880

Lebertia (*Lebertia*) *glabra* Thor, 1897

Materials examined: Elazığ province, Arıcak district, Akdağlar mountain, low order streams, 38°37'56" N, 40°08'00" E, 2145 m a.s.l., 05.07.2018, (11/13/0); Sivrice district, Sürek village, spring, 38°27'05" N, 39°21'49" E, 1290 m a.s.l., 13.07.2013, (0/1/0).

Records from Türkiye: Niğde (Smit, 1995), Malatya (Esen and Erman, 2012), Antalya (Boyacı et al., 2012), Erzincan (Esen et al., 2013), Siirt (Esen and Erman, 2015), Burdur (Gülle et al., 2017) and Isparta (Durucan and Boyacı, 2020).

Lebertia (*Lebertia*) *fimbriata* Thor, 1899

Materials examined: Elazığ province, Arıcak district, Akdağlar Mountain, low order streams, 38°37'56" N, 40°08'00" E, 2145 m a.s.l., 05.07.2018, (1/1/0).

Records from Türkiye: Bingöl (Esen and Erman, 2013), Erzincan (Esen et al., 2013), Çanakkale (Gülle et al., 2014), Adıyaman (Beyaz et al., 2016) and Isparta (Durucan and Boyacı, 2020).

Lebertia (*Mixolebertia*) *sefvei* Walter, 1911

Material examined: Elazığ province, Arıcak district, Akdağlar Mountain, low order streams, 38°37'56" N, 40°08'00" E, 2145 m a.s.l., 05.07.2018, (0/1/0).

Records from Türkiye: Malatya (Esen and Erman, 2012).

Family: TORRENTICOLIDAE Piersig, 1902

Genus *Torrenticola* Piersig, 1896

Torrenticola (*Torrenticola*) *barsica* (Szalay, 1933)

Materials examined: Elazığ province, Arıcak district, Akdağlar Mountain, low order streams, 38°37'56" N, 40°08'00" E, 2145 m a.s.l., 05.07.2018, (5/12/2).

Records from Türkiye: Rize, Artvin (Erman et al., 2010), Malatya (Esen and Erman, 2012), Bingöl (Esen and Erman, 2013), Erzincan (Esen et al., 2013), Çanakkale (Gülle et al., 2014), Siirt (Esen and Erman, 2015), Adıyaman (Beyaz et al., 2016), Isparta (Durucan and Boyacı, 2020).

Remarks: Recently Pešić et al. (2023) using molecular DNA barcoding techniques showed that *T. barsica* like specimens from southeastern Türkiye belongs to *T. baueri*

Bader and Sepasgozarian, 1987. The latter authors suggested the former records of *T. barsica* from Türkiye likely should be assigned to *T. baueri*.

Torrenticola (*Torrenticola*) *brevirostris* (Halbert, 1911)

Materials examined: Elazığ province, Arıcak district, Akdağlar Mountain, low order streams, 38°37'56" N, 40°08'00" E, 2145 m a.s.l., 05.07.2018, (7/13/1).

Records from Türkiye: Rize, Afyon, Erzurum (Erman et al., 2010), Malatya (Esen and Erman, 2012), Antalya (Boyacı et al., 2012), Bingöl (Esen and Erman, 2013), Erzincan (Esen et al., 2013), Siirt (Esen and Erman, 2015), Adıyaman (Beyaz et al., 2016), Isparta (Durucan and Boyacı, 2020).

Family: HYGROBATIDAE Koch

Genus: *Atractides* Koch

Subgenus *Atractides* Koch

***Atractides* (*Atractides*) *ermani* sp. nov.**

https://zoobank.org/6E34FF3B-DB83-4486-9E1A-284643349C33

Type material: Holotype: male, dissected and slide mounted in Hoyer's fluid; Elazığ province (Türkiye), Alacakaya district, Halkalı village, spring and low order streams, 38°32'44" N, 39°56'22" E, 1507 m a.s.l., 12.07.2020, leg. Esen. Paratype, same data as holotype, ibid., 23.08.2020 (1/0/0).

Diagnosis (*male*): Integument finely striated, muscle attachment unsclerotized. Coxal field: posterior margin Cx-1+2 slightly protruding. Genital field wider than long, L/W ratio 0.68-0.69, with acetabula in triangular arrangement, genital plate posterior margin indented. Excretory pore sclerotized; Vgl-1 not fused to Vgl-2. P-2 with strongly developed ventrodistal protrusion with a few pointed dents, P-4 sword seta halfway between ventral setae; I-L slightly modified, I-L-5 with S-1 and S-2 rod-shaped, with blunt tips, close together. I-L-6 short and stout, weakly curved.

Description: *Male* (measurements of paratype given in parentheses): Length of idiosoma 410 (393), width 352 (344). Dorsally integument is finely striated. Muscle attachments, unsclerotized. Dgl-3 length 30 (29). Coxal field (Fig. 1A); posterior margin Cx-1+2 medially slightly protruding, with large protruding apodemes, coxal field length 312 (297), Cx-3 width 310 (305), Cx-1+2 width 258 (255), Cx-1+2 medial suture line 112 (110) in length; distance from lateralmost tips of Cx-2 to the medioposterior edge of Cx-1+2 216 (210). Measurements of mouthparts: chelicera 207 (200) in length, claw 57 (55) in length; palp total length 270 (265), dorsal length of single segments; P-1 31 (30), P-2 65 (65), P-3 64 (62), P-4 80 (78), P-5 30 (30); relative length (% total length) of single segments: P-1 11.5 (11.3), P-2 24.1 (24.5), P-3 23.7 (23.4), P-4 29.6 (29.4), P-5 11.1 (11.3); ratio length P-2/P-4 is 0.81 (0.83), P-3 39 (38), P-4 32 (31) in height; palp (Figs 1B, 2A): P-2 ventrodistally strongly protruding, with 2-3 pointed dents, P-3 straight, P-4 strongly thickened, well developed denticle near each ventral hair insertion, divided by ventral setae in sectors 2:1:1, sword seta halfway between ventral hairs. Genital field: L/W 95 (90) / 139 (130), Ac-1-3 length 40 (34), 38 (35), 34 (28).

I-L (Figs 1C, 2B): little modified, I-L-5 slightly enlarged distally, S-1 and S-2 very close to each other, short, blunt and similar in shape; I-L-6 short, thickened and weakly curved; I-L-5 dL 127 (125), HA 30 (29), HB 40 (40), vL 101 (100); S-1 41 (40), S-2 37 (35) in length; I-L-6 112 (108) in length, central H 36 (35); ratio dL I-L-5/I-L-6 1.13 (1.16).

Female and immature stages: Unknown.

Remarks: Due to the strongly projected ventrodistal protrusion on P-2 and similar morphology of I-L (I-L-5 with short, equally rod-shaped sword setae and the stout, slightly modified I-L-6), the male of new species resembles *Atractides dentipalpis* (Walter, 1935) and *A. turcicus* Aşçı, 2009.

Atractides dentipalpis was originally described from Algeria on the basis of a female specimen (Walter, 1935). Later, Boyacı (2007) reported *A. dentipalpis* from Isparta, Türkiye on the basis of both female and male sexes, and presented the first description of the male. Compared with the female specimens from Isparta, assigned by Boyacı (2007) to *A. dentipalpis*, the female holotype from Algeria clearly differs in less projected ventrodistal projection on P-2, comparatively more stouter palpal segments, and the presence of an unpaired sclerite between Cx-IV and genital field (see Gerecke 2003). It is likely that specimens reported and illustrated by Boyacı (2007) are not conspecific with *A. dentipalpis*, a species that is currently known with certainty only from Algeria. The shape of palp and I-L in specimens described by Boyacı (2007) show general conformity with the male specimens from Elazığ, which are described here as a new species. The difference was found in a male genital plate being wider than long, and with indented posterior margin in the new species (*vs.* genital plate longer than wider, with nearly straight posterior margin in male specimen from Isparta (see Boyacı, 2007). A more detailed comparison of males is made in table 1. Further sampling was needed to test variability to determine whether these populations in Isparta and Elazığ were conspecific.

Atractides turcicus was described by Aşçı (2009) on the basis of a male and female collected in a stream at the Rize Province in the eastern Black Sea coast of Türkiye. The holotype of this species may be missing, is it not found at Zoology Museum of Atatürk University (Erzurum, Türkiye). According to the original description, Aşçı (2009) stated that presence of pointed sword setae on I-L-5, makes *A. turcicus* most similar to *A. subterraneaus*, which can easily be separated by the characteristic shape of genital field, and palp without distinct protrusion on P-2 (Gerecke, 2003). Based on the original description, *A. turcicus* differs from the new species (in parentheses) in the setae S-1 and -2 with pointed tips (sword setae rod-

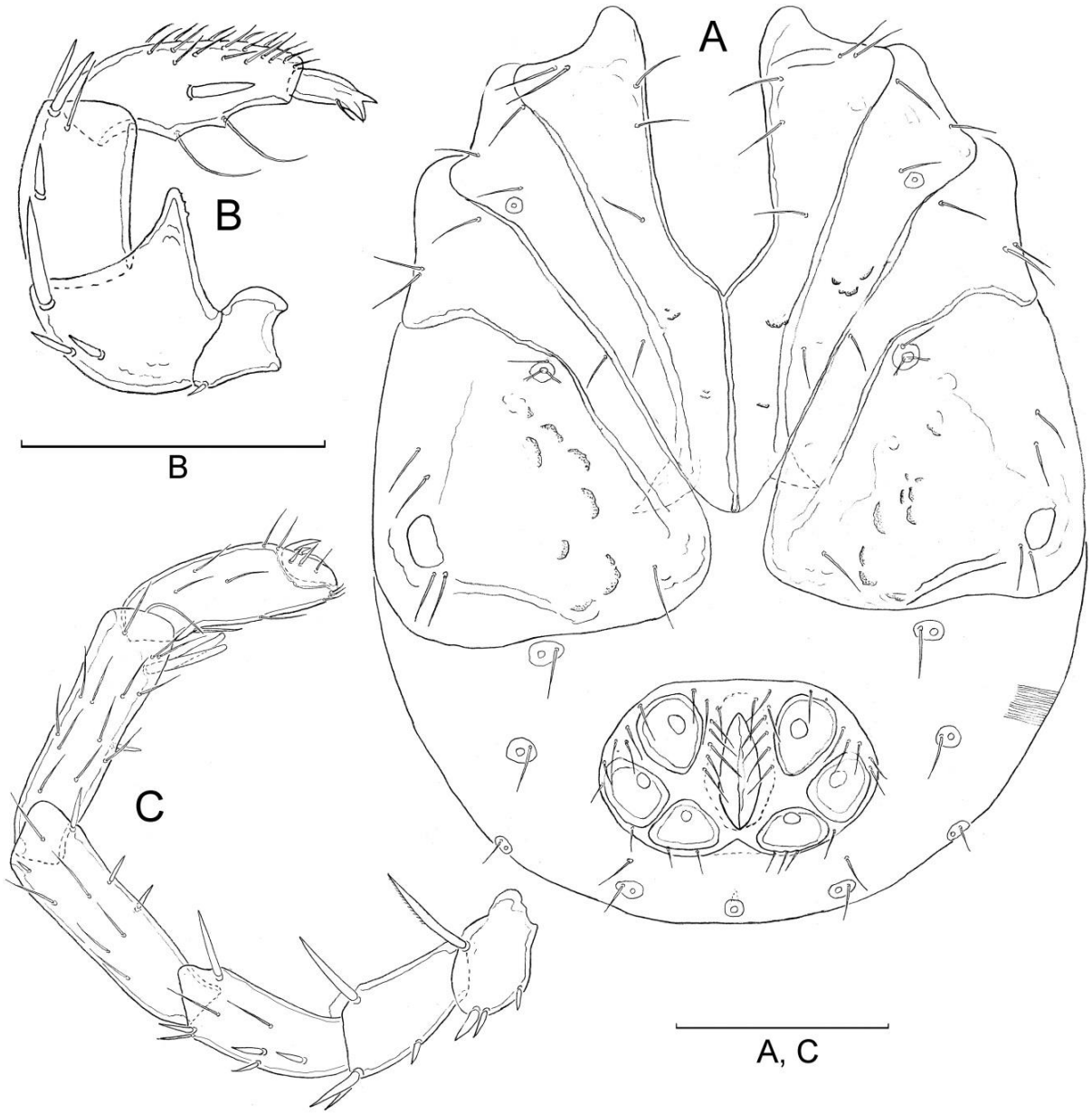

Figure 1. *Atractides* (*Atractides*) *ermani* sp. nov. (male). **A.** Idiosoma, ventrally, **B.** Palp, medial view, **C.** I-L (Scale bars=100).

Figure 2. *Atractides* (*Atractides*) *ermani* sp. nov. male. **A.** Gnathosoma, **B.** I-L-5-6 (Scale bars = 100).

Table 1. Comparison of males of *Atractides dentipalpis* and *A. ermani.*

Body part	*A. dentipalpis*	*A. ermani*
Idiosoma L / W	590 / 400	393-410 / 344-352
Chelicerae L	200	200-207
Coxal field L	287	297-312
Cx-1+2 W	250	255-258
Cx-1+2 mL	115	110-112
Cx-3 W	315	305-310
Palp segments dL and total L	25-63-62-77-22 = 249	30(31)-65(65)-64(62)-78(80)-30(30) = 265(270)
Genital field L / W	125 / 108	90-95 / 130-139
I-L-5-6 dL	102-96	(125-127)-(108-112)

shaped, with blunt tips), P-2 ventrodistal projection covered by a fine denticles (P-2 extension with 2-3 pointed dents) and a comparatively less wider genital plate (see Aşçı, 2009).

Etymology: The species is named in honour of Professor Orhan Erman (Fırat University, Elazığ, Türkiye) in appreciation of his studies on the Turkish water mites.

Biology: *Atractides ermani* sp. nov. is a crenobiontic species, which inhabits springs.

***Atractides* (*Atractides*) *elazigensis* sp. nov.**

https://zoobank.org/12FF196B-5D6B-4325-B91E-6F3C77E3F41F

Type series: Holotype: male, dissected and slide mounted in Hoyer's fluid; Elazığ province (Türkiye), Alacakaya district, Halkalı village, spring and low order streams, 38°32'44" N, 39°56'22" E, 1507 m a.s.l., 12.07.2020, leg. Y. Esen. Paratypes: same data as holotype (1/1/0); ibid., 23.08.2020 (1/1/0).

Diagnosis: Integument lineated; muscle insertions unsclerotized. Genital field with acetabula in an obtuse triangle. Excretory pore smooth; Vgl-3 not fused to Cx-IV; Vgl-1 not fused to Vgl-2. Palp with weak sexual dimorphism, ventral margin of P-2 distally protruding, without projection; I-L-5/6 larger (L I-L-5/6 ♂ >170/ >130, ♀ > 300/200); S-1/2 longer (S-1/2 > 100/80 in ♂, > 130/100 in ♀), S-1 long, with truncate tip, S-2 shortened, enlarged; I-L-6 slender and long, I-L-5/6 >1.3. Male: P-4 sword seta nearer to distoventral seta, S-1-2 separation 20-25. Female: P-4 sword seta between ventral setae, S-1-2 separation 28-31.

Description. Male (measurements of paratype given in parentheses) Length of idiosoma 430 (413), width 365 (375). Dgl-3 length 20 (21). Coxal field (Fig. 3A); coxal field length 317 (308), Cx-3 width 337 (314), Cx-1+2 width 288 (285), Cx-1+2 medial suture line 127 (118) in length. Measurements of mouthparts: chelicera 200 (160) in length, claw 60 (53), palp (Figs 3B, C) total length 331 (323), dorsal length of single segments P-1 37 (35), P-2 75 (74), P-3 74 (72), P-4 110 (107), P-5 35 (35), P-3 49 (47) in height, P-4 38 (36) in height; relative total length (% total length) of single segments: P-1 1.1, P-2 22.7 (22.9), P-3 22.4 (22.3), P-4 33.2 (33.1), P-5 1.1; ratio length P-2/P-4 is 0.68 (0.69). Genital field (Fig. 3A), L/W 110/131 (98/132), Ac-1-3 length 39 (38), 45 (32), 52 (33).

I-L (Fig. 3D), I-L-5 dL 190 (180), vL 125 (119), HA 47 (44), HB 55 (50), I-L-6 length 145 (138), central H 21 (20), ratio length I-L-5/I-L-6 1.31 (1.30), S-1 length 106 (100), S-2 length 85 (80), distance between sword seta of I-L-5 25 (20).

Female (n=2) Length of idiosoma 780 (770), width 672 (680). Dgl-3 length 24 (22). Coxal field (Fig. 4A); coxal field length 430 (380), Cx-3 width 563 (498), Cx-1+2 width 460 (342), Cx-1+2 medial suture line 160 (125) in length. Measurements of mouthparts: chelicera 302 (260) in length, claw 90 (73), palp (Fig. 4C) total length 509 (394), dorsal length of single segments P-1 47 (40), P-2 111 (91), P-3 141 (102), P-4 160 (120), P-5 50 (41), P-3 58 (50) in height, P-4 32 (30) in height; relative total length (% total length) of single segments: P-1 0.9 (1.1), P-2 21.8 (23.1), P-3 27.7 (25.9), P-4 31.4 (30.5), P-5 1.0; ratio length P-2/P-4 is 0.69 (0.76). Genital field (Fig. 3D), L/W 190/202 (187/203), Ac-1-3 length 67 (45), 87 (47), 88 (66). Vgl-1 not fused to Vgl-2 (Fig. 4B).

I-L (Fig. 4E), I-L-5 dL 330 (303), vL 247 (230), HA 75 (71), HB 88 (81), I-L-6 length 222 (206), central H 24 (22), ratio length I-L-5/I-L-6 1.49 (1.47), S-1 length 142 (135), S-2 length 115 (102), distance between sword setae of I-L-5 31 (28).

Immature stages: Unknown.

Remarks. The new species resembles *Atractides panniculatus* (K. Viets, 1925) and *A. rivalis* Lundblad, 1956. The latter two species share the following characters with the new species: a lineated integument, a similar shape of the palp (male P-2 ventrodistal margin convexly protruding, without projection), and the distal position of the sword seta on P-4 in male. From the latter two above mentioned species, the new species differ in acetabula arranged in an obtuse triangle rather than in a triangular position as in *A. panniculatus* and *A. rivalis*. *Atractides panniculatus* differs in the male in a larger I-L-5/6 (L >200/>150, a stouter P-3 (L/H <1.6) and Vgl-3 fused to Cx-IV and a S-1-2 separation wider in the both sexes (> 30 in ♂, >35 in ♀).

Atractides rivalis can be separated by the male genital field much wider than long (L/W ratio 0.77, data taken from Gerecke 2003) and sword setae on I-L-5 shorter in the both sexes (L S-1/2 ♂: < 100/80, ♀: < 115/90). The both, *A. panniculatus* and *A. rivalis* have been reported from Türkiye by Pešić and Erman (2006), but with a

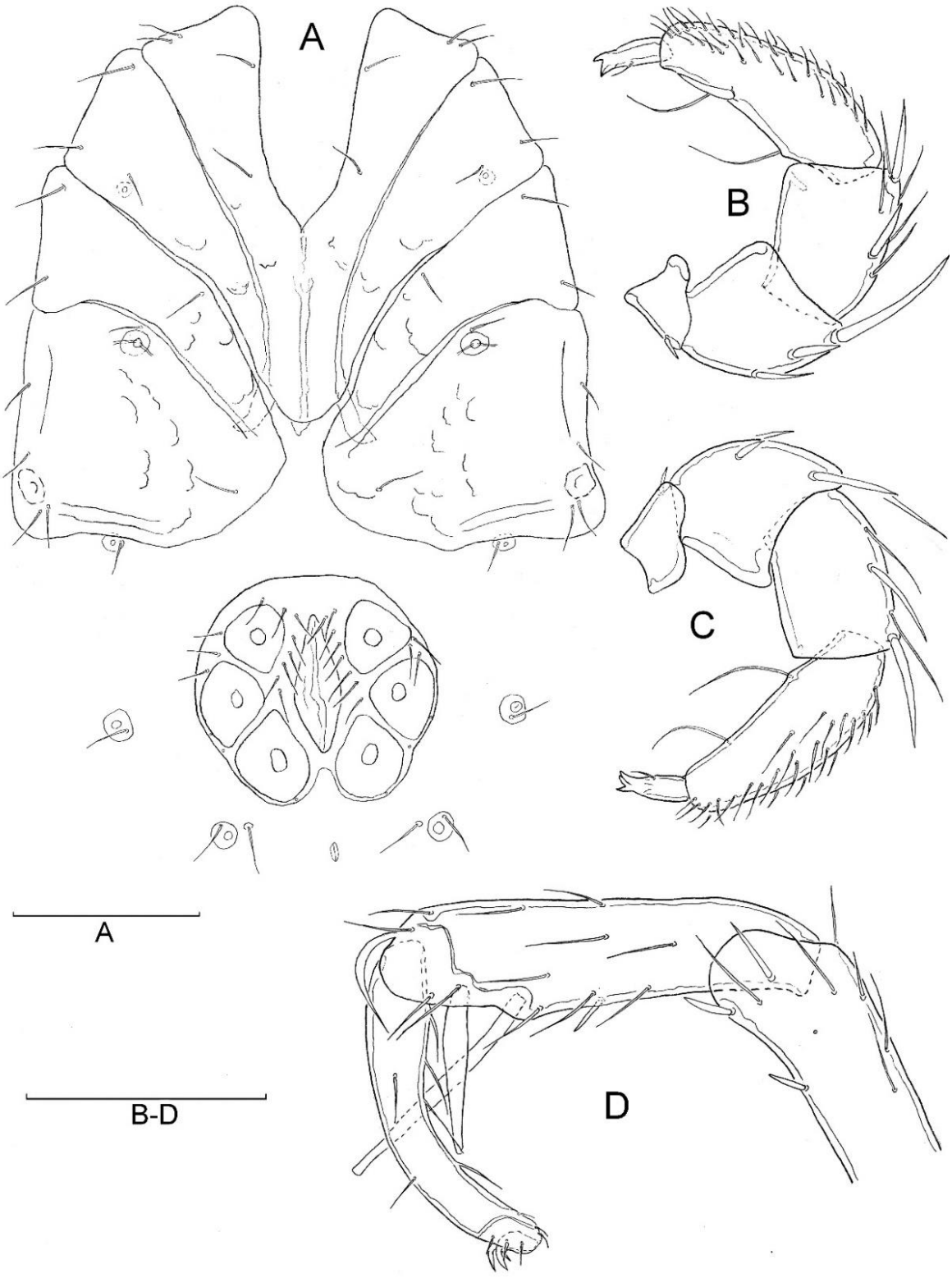

Figure 3. *Atractides* (*Atractides*) *elazigensis* sp. nov. male. **A.** Coxal and genital field, **B.** Palp, medial view, **C.** Palp, lateral view, **D.** I-L-5/6 (Scale bars = 100).

statement that future investigations on these species likely prove that this taxon represents a species complex. Concerning general morphology and measurement range the males of *Atractides elazigensis* sp. nov. shows general agreement with the male specimens assigned by Pešić and Erman (2006) to *A. panniculatus*. However, the specimens assigned by Pešić and Erman (2006) to *A. panniculatus* differs in male by P-4 ventral setae inserted far apart dividing ventral margin of the segment in sectors 2:3:1 and seta S-1 with oblique, not truncate tip. Additional sampling and possible applying a molecular method are needed to clarify relationship of these populations.

Atractides (Atractides) graecus K.Viets, 1950

Materials examined: Elazığ Province, Sivrice district, Sürek village, spring, 38°27'05" N, 39°21'49" E, 1290 m a.s.l., 13.07.2013, (2/5/0).

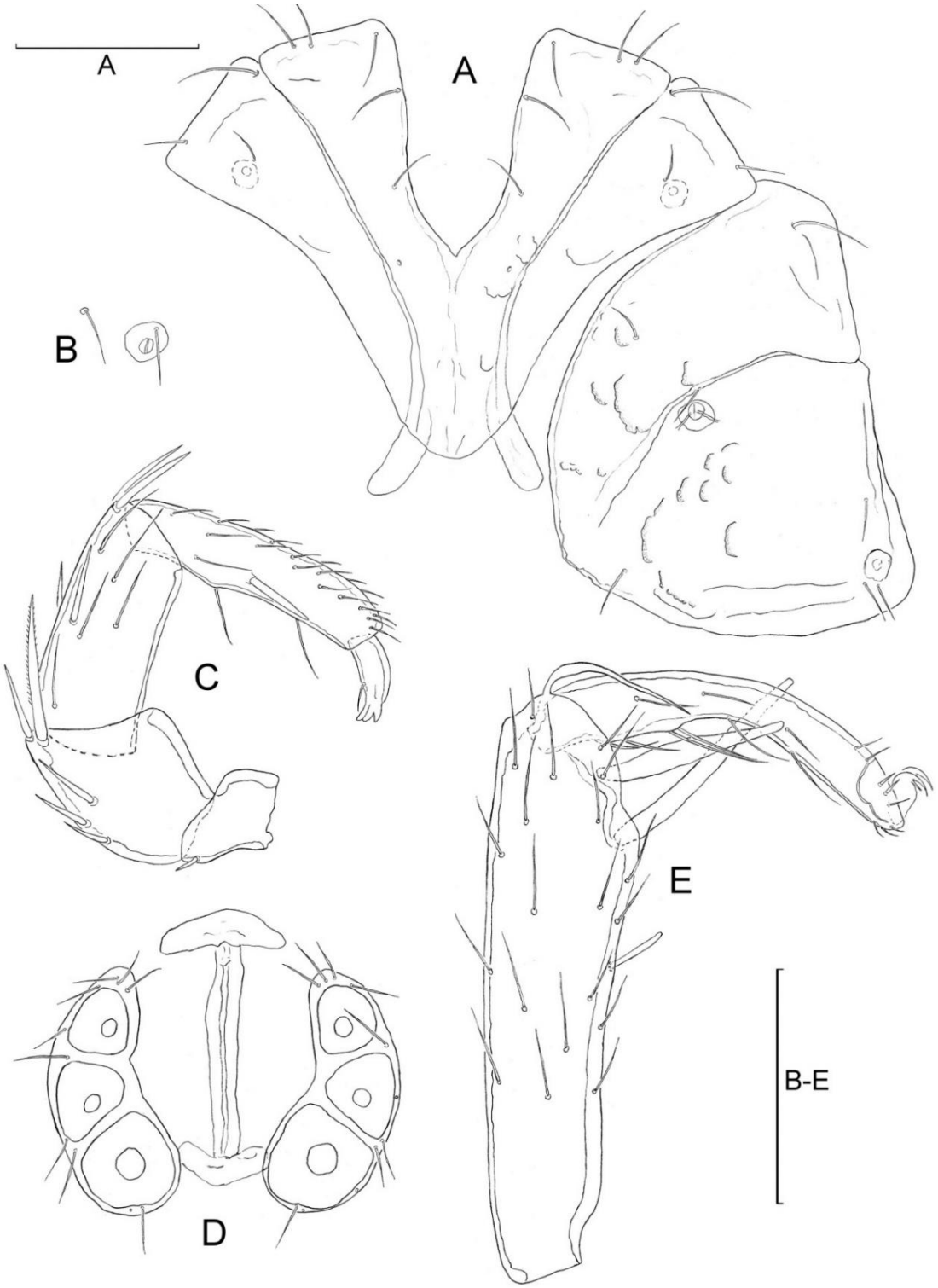

Figure 4. *Atractides* (*Atractides*) *elazigensis* sp. nov. female. **A.** Coxal field, **B.** Vgl-1 and Vgl-2, **C.** Palp, medial view, **D.** Genital field, **E.** I-L-5/6 (Scale bars = 100).

Records from Türkiye: Bingöl (Esen and Erman, 2013), Erzincan (Esen et al., 2013), Siirt (Esen and Erman, 2015), Adıyaman (Beyaz et al., 2016) and Burdur (Gülle et al., 2017).

Atractides (*Atractides*) *panniculatus* (Viets, 1925)

Materials examined: Elazığ province, Arıcak district, Akdağlar mountain, low order streams, 38°37'56" N, 40°08'00" E, 2145 m a.s.l., 05.07.2018, (1/2/0).

Records from Türkiye: Van, Elazığ, Malatya, Afyon, Erzurum (Erman et al., 2010; Esen and Erman, 2012), Bingöl (Esen and Erman, 2013), Erzincan (Esen et al., 2013), Siirt (Esen and Erman, 2015) and Adıyaman (Beyaz et al., 2016).

Family: FELTRIIDAE K. Viets, 1926

Genus *Feltria* Koenike, 1892

Feltria (*Feltria*) *minuta* Koenike, 1892

Materials examined: Elazığ province, Arıcak district, Akdağlar mountain, low order streams, 38°37'56" N, 40°08'00" E, 2145 m a.s.l., 05.07.2018, (1/3/0).

Records from Türkiye: Erzurum (Erman et al., 2010) and Antalya (Boyacı et al., 2012).

Family: ATURIDAE Thor, 1900

Genus: *Kongsbergia* Thor, 1899

Kongsbergia (*Kongsbergia*) *materna* Thor, 1899

Materials examined: Elazığ province, Arıcak district, Akdağlar mountain, low order streams, 38°37'56" N, 40°08'00" E, 2145 m a.s.l., 05.07.2018, (1/1/0).

Records from Türkiye: Afyon, Erzurum (Erman et al., 2010), Antalya (Boyacı et al., 2012), Erzincan (Esen et al., 2013) and Isparta (Durucan and Boyacı, 2020).

Family: ARRENURIDAE Thor, 1900

Genus: *Arrenurus* Dugès, 1834

Arrenurus (*Truncaturus*) *fontinalis* Viets, 1920

Materials examined: Elazığ Province, Sivrice district, Sürek village, spring, 38°27'05" N, 39°21'49" E, 1290 m a.s.l., 13.07.2013, (1/1/0).

Records from Türkiye: Erzurum (Erman et al., 2010), Malatya (Esen and Erman, 2012), Antalya (Boyacı et al., 2012), Bingöl (Esen and Erman, 2013), Erzincan (Esen et al., 2013), Burdur (Gülle et al., 2017) and Isparta (Durucan and Boyacı, 2020).

DISCUSSION

Studies on water mites from Türkiye have been increased over the last two decades. Erman et al. (2010, 2019) listed 236 (in 23 families, 52 genera) and 335 (in 25 families, 62 genera) water mite species, respectively. Nevertheless, most of the provinces of Türkiye are not studied extensively. So, only 18 of 81 provinces were studied on water mites within the scope of a project or postgraduate thesis (Fig. 5). Bingöl (142 species), Isparta (119), Erzurum (102), Burdur (81), Afyon (80), Elazığ (76) and Erzincan (77) provinces are richest in number of species based on recent published data (Table 2). Some provinces were studied within a postgraduate thesis (e.g. Kars, Ardahan, Rize, Artvin, Van, Konya provinces) but the findings were not published. Twenty three provinces shown in yellow colour in the map (Fig. 5) were not studied comprehensively and there are only a few records of water mite species. It is clear that studies on water mite fauna of Türkiye are largely incomplete (Erman et al., 2010, 2019).

In this study, twenty water mites were identified, including two new species; *Atractides* (*Atractides*) *ermani* sp. nov. and *A.* (*Atractides*) *elazigensis* sp. nov. *Hydrovolzia cancellata, Panisus torrenticolus, Protzia rotunda, S.* (*Hispidosperchon*) *clupeifer, Sperchonopsis verrucosa, Nilotonia* (*Manotonia*) *tegulata, Lebertia* (*Lebertia*) *glabra, L.* (*Lebertia*) *fimbriata, L.* (*Mixolebertia*) *sefvei, Torrenticola* (*Torrenticola*) *barsica, T.* (*Torrenticola*) *brevirostris, Atractides* (*Atractides*) *graecus, Feltria* (*Feltria*) *minuta, Kongsbergia* (*Kongsbergia*) *materna* and *Arrenurus* (*Truncaturus*) *fontinalis* are new record for Elazığ province. Hydrovolziidae and Feltriidae are firstly recorded from Elazığ province. With the records of this study, the number of known water mite species of Elazığ Province reaches to 76 species.

Figure 5. Map of provinces of Türkiye studies on water mites within the scope of a project or postgraduate thesis and limited individual works.

Table 2. The number of water mite species recorded from the Turkish provinces in alphabetical order.

Province	Numbers of species	Province	Numbers of species	Province	Numbers of species
Adana	2	Elazığ	76	Mardin	-
Adıyaman	2	Erzincan	77	Mersin	7
Afyon	76	Erzurum	102	Muğla	-
Ağrı	4	Eskişehir	14	Muş	18
Aksaray	1	Gaziantep	-	Nevşehir	1
Amasya	-	Giresun	-	Niğde	2
Ankara	-	Gümüşhane	-	Ordu	-
Antalya	69	Hakkâri	8	Osmaniye	-
Ardahan	1	Hatay	-	Rize	38
Artvin	14	Iğdır	-	Sakarya (Adapazarı)	-
Aydın	-	Isparta	119	Samsun	-
Balıkesir	-	İstanbul	-	Şanlıurfa	-
Bartın	-	İzmir	3	Siirt	65
Batman	-	Kahramanmaraş	19	Sinop	2
Bayburt	4	Karabük	-	Sivas	-
Bilecik	-	Karaman	1	Şırnak	-
Bingöl	142	Kars	3	Tekirdağ	-
Bitlis	10	Kastamonu	-	Tokat	6
Bolu	-	Kayseri	50	Trabzon	2
Burdur	81	Kilis	-	Tunceli	-
Bursa	-	Kırıkkale	-	Uşak	-
Çanakkale	11	Kırklareli	-	Van	19
Çankırı	-	Kırşehir	-	Yalova	-
Çorum	-	Kocaeli (İzmit)	-	Yozgat	2
Denizli	2	Konya	20	Zonguldak	1
Diyarbakır	1	Kütahya	-		
Düzce	2	Malatya	62		
Edirne	-	Manisa	-		

Authors' contributions

Yunus Esen: Fieldwork, collection of samples, microscopic examinations (measurements, drawing), methodology, investigation. **Vladimir Pešić:** Identification of mites, writing-editing, methodology, investigation.

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RESEARCH ARTICLE

Histological structures of the midguts of adult *Rhipicephalus bursa* and *Rhipicephalus turanicus* ticks (Acari: Ixodidae)

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ABSTRACT: Ticks play a role in the natural cycle of approximately 200 pathogens and are responsible for the transmission of various pathogens, such as *Babesia*, *Theileria*, *Borrelia*, *Rickettsia* and *Anaplasma*, to humans and animals. The midgut of ticks is the first organ to come into contact with tick-borne pathogens during the blood meal. When pathogens are acquired from infected hosts via the blood meal, they are trapped in the lumen of the midgut. The structure and function of the midgut of ticks are very important for understanding the ecology and transmission of tick-borne pathogens; therefore, a more detailed and comprehensive understanding of their biology is required. To this end, this study examined the histomorphology of the midgut of *Rhipicephalus bursa* Canestrini and Fanzago and *R. turanicus* Pomerantzev using histological methods, for the first time from Türkiye. In both species, the midgut was found to consist of a pseudostratified epithelium surrounded by a thin muscular layer. However, within their epithelium there are different digestive cells, one of which is a stem cell and the others have different characteristics, such as having more or less granules in their cytoplasm and with a clear cytoplasm.

Keywords: Acari, cell, diseases, histology, pathogens, zoonoses

Zoobank: https://zoobank.org/2B05C4F4-84D0-45B8-9BE1-AEF768BD35A6

INTRODUCTION

Ticks (Ixodida), also called as “sakırga, yavsı, kerni” by the Turkish people, can be found in every region of the world. More than 1000 tick species have been identified within the five families today, and they are external parasites that must feed on blood in order to survive, shed their skin and lay eggs (Merdivenci, 1969; Sonenshine et al., 2002; Keskin and Bakırcı, 2023).

Ticks play a role in the natural cycle of about 200 pathogens and cause various diseases in their hosts, such as babesiosis, louping ill, Lyme borreliosis, tropical theileriosis, rickettsial infections, tularemia, ehrlichiosis and anaplasmosis. Due to its geographical location and its biological richness, Türkiye is supply constitutes a suitable habitat for many species of tick, therefore, tick-borne diseases are also widespread in this country. The most tick-borne disease in our country is Crimean-Congo haemorrhagic fever (CCHF). CCHF is a disease that can cause asymptomatic infections in animals while in humans it can cause severe symptoms that can lead to death (Horak et al., 2002; Tekin et al., 2012).

In arthropods, the digestive system is in the form of a straight channel that starts at the mouth and ends at the anus. This channel consists of three parts: foregut, midgut and hindgut. The foregut generally only plays an active role in food intake and sometimes in digestion by pushing digestive secretions forward. The midgut is where digestive secretions are produced, and the hindgut is responsible for the formation of faeces and the reabsorption of water excreted with the faeces. Depending on the lifestyles and eating habits of the animals, the length of the intestine is shorter in those fed on meat, longer in those fed on grass and longest in those fed on faeces (Elzinga, R.J., 1998; LaDouceur et al., 2021; Özman-Sullivan et al., 2023).

The midgut is the largest organ in the tick’s body. It is responsible for the digestion of all the blood ingested while feeding on the host. The midgut of ticks consists of a central ventricle (stomach), several diverticula or caecae that extend in three planes of the body and fill almost the entire cavity, and a long, narrow "tube" through which undigested residues pass (Caperucci et al., 2009). Histologically, the midgut is surrounded by circular and longitudinal muscle layers and consists of an epithelium overlying the basement membrane (Sonenshine, 1991; Caperucci et al., 2009).

According to some authors, the midgut epithelium consists of two basic cell types: undifferentiated or generative cells and digestive cells, which respond differently to the physiological conditions of the tick and have different activities. The digestive cells consist of generative cells that differentiate during the feeding period (Sonenshine, 1991). However, other authors have reported six groups of cells in the tick midgut: (1) regenerative, (2) digestive, (3) secretory, (4) undifferentiated, (5) endocrine and (6) vitellogenic cells. Except for vitellogenic cells, all others are characterised only by their morphology. Generative cells are undifferentiated cells that can give rise to other cell types and are located near the basement membrane (Grandjean and Aeschlimann, 1973).

The midgut of ticks is not only responsible for digesting ingested blood, but is also the first major region of the body where intense interaction with pathogens occurs

(Heekin et al., 2013; Xu et al., 2016). In order to effectively control ticks, their biology needs to be studied in more detail and comprehensively. To this end, this study comparatively investigated the morphology and ultrastructure of the midgut of *Rhipicephalus bursa* Canestrini & Fanzago and *R. turanicus* Pomerantzev using histological methods, and it is believed that it will form the basis for more comprehensive research in the future.

MATERIALS AND METHODS

Sample collection

Adult male tick specimens of *Rhipicephalus bursa* and *R. turanicus* collected from cows and sheep in different villages of Tokat, Sinop and Tekirdağ provinces (Türkiye) were used in the study. After the tick specimens were removed from the host, they were immediately placed in 70% alcohol and taken to the Parasitology Laboratory, Department of Biology, Tokat Gaziosmanpaşa University (Türkiye).

Light microscopic research

Tick specimens were dissected under a stereomicroscope (Olympus SZ61, Olympus Corp., Tokyo, Japan) in 0.1 M PBS (dissection medium) according to Edwards et al. (2009). For light microscopy, the removed midgut was washed in freshly prepared PBS buffer (pH = 7.4) and then fixed in 10% neutral formalin fixative for 24 hours. After overnight washing in tap water, the tissues were dehydrated through an ascending series of alcohols (70%, 80%, 90%, 96%, 100% and 100%) and cleared in xylene. The tissues were then processed into paraffin blocks and 6-7 µ thick sections were taken from the prepared paraffin blocks using a microtome (Microm HM 315, Walldorf, Germany). The sections were stained with hematoxylin and eosin (H&E) dye (Özban and Özmutlu, 1991), examined under a microscope with a camera attachment (Nikon Optiphot-2, Nikon Coolpix P7100, Japan) and photographed.

RESULTS

In this study it was observed that the digestive tract of ticks of the species *Rhipicephalus bursa* and *R. turanicus* consists of three parts: foregut, midgut and hindgut. Laterally extending caecae can be seen as a pair branched on the right and left at the junction of the foregut and midgut of both species. Malpighian tubes are located at the junction of the midgut and hindgut.

There is a thin layer of muscle around the midgut of *R. turanicus.* The midgut epithelium was observed to consist of a single layer of cuboidal or cylindrical cells. There are two types of cells in the epithelium. One type is the stem or generative cells with smaller and darker nuclei located at the basal base. The other type is the cylindrical or cubic digestive cells, which extend into the lumen. While some types of digestive cells have dense, dark granules in their cytoplasm, other types have less granules and a clear cytoplasm. Host cells can also be seen in the lumen. Caecae are seen at the junction of the foregut and midgut. Malpighian tubes consist of a monolayer of cuboidal epithelium with 8-10 cells and eosinophilic cytoplasm (Fig. 1).

It has also been observed that *R. bursa* consists of a thin layer of muscle around the midgut and an epithelium consisting of a single layer of cuboidal or cylindrical cells. Within the epithelium there are stem cells and digestive cells with similar properties to *R. turanicus*. However, the stem cells are more cuboidal than *R. turanicus* and there are more less granules in the digestive cells. There are also non-granular digestive cells in the epithelium. It was also observed that the densely granulated digestive cells were not as numerous as in *R. turanicus*. Host cells are also present in the lumen. Caecae are present at the junction of the foregut and midgut. Malpighian tubes consist of a monolayer of cuboidal epithelium with 6-8 eosinophilic cytoplasms (Fig. 2).

DISCUSSION

The morphological description of the internal organs of ticks can be considered as an important parameter in parasitology. Defining the structure of the midgut is of great importance for studies of parasite development and other methods of acaricide application. Although the midgut morphology of some tick species has been described by researchers over the last 30 years, many differences have been observed, especially in the identification of cell types, and a wide range of results have been obtained even in species of the same family (Remedio et al., 2013).

Caperucci et al. (2009) studied the digestive tract of *Amblyomma cajennense* (Fabricius) and found that the digestive tract consists of three parts: foregut, midgut and hindgut. In a previous study, it was reported that the digestive tract of *Nuttalliella namaqua* Bedford consists of mouth, pharynx, esophagus, stomach and rectum. The short and wide mid-stomach and its lateral lobes form the caecae and Malpighian tubes, which fill most of the body cavity and are reported to surround other organs (El Shoura et al., 1984). In the present study, the digestive tract of *R. bursa* and *R. turanicus* ticks was found to correlate with this information in the literature.

Veronez et al. (2010) fed *Rhipicephalus sanguineus* (Latreille) on dogs and guinea pigs and examined changes in the midgut, trachea, Malpighian tubes and oocytes of these ticks. According to the results of this study, it has been reported that the midgut enlarges depending on the feeding time of the ticks with the host species, the occurrence of oocytes changes, and there are leukocytes and various pigments belonging to the host blood in the trachea, Malpighian tubes and midgut lumen and cells. As a result, it has been emphasized that such organs of ticks contain target structures for tick vaccines.

Tafur-Gómez et al. (2020) examined the midgut of *Rhipicephalus microplus* (Canestrini) feeding on immunized cattle. They reported that the midgut epithelium of the ticks feeding on unimmunized cattle consisted mainly of stem cells, enlarged cylindrical pre-digestive cells with slightly elongated and rounded, dark-

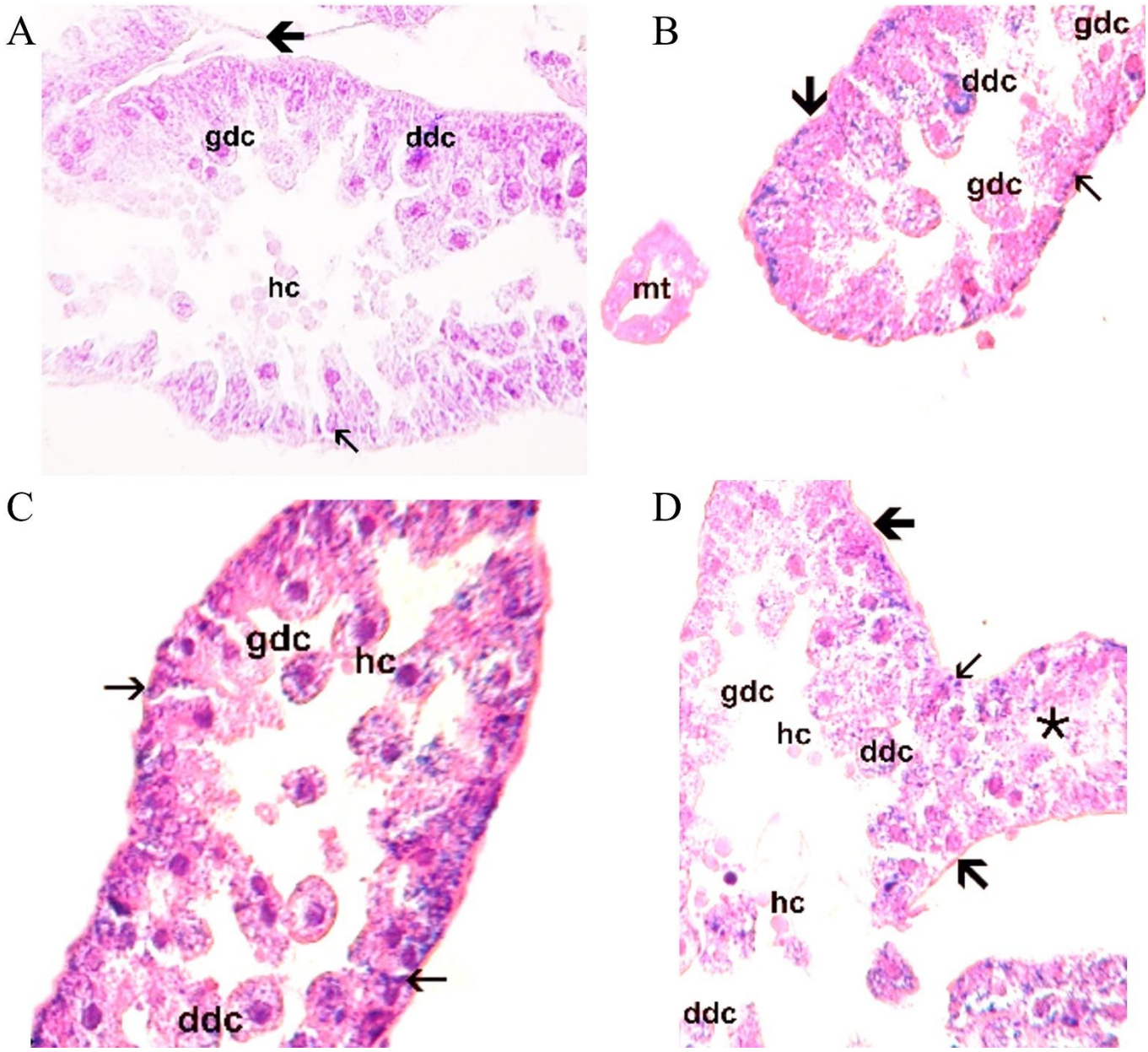

Figure 1. Histology of the digestive tract of the midgut of *Rhipicephalus turanicus*. ←: muscle layer, ✶: caecae, ←: stem (generative) cell, gdc: granular digestive cell, ddc: densely granulated digestive cell, hc: host cell, mt: Malpighian tube. X400, H&E.

stained nuclei in contact with the basement membrane, and digestive cells adjacent to the basement membrane and extending into the lumen. All differentiated digestive cells were observed to contain haematin granules and amorphous granules with heterogeneous contents. In the same ticks, there is both a basal lamina and a smooth muscle layer around the epithelium. Although the midgut of ticks fed on immunized cattle showed the same histological features, pathological changes such as necrosis, vacuolization, erosion of the basement membrane, degeneration of the nucleus and deterioration of the muscle layer were observed in the digestive cells.

It has been reported that the midgut of *N. namaqua* is histologically composed of small, undifferentiated epithelial cells with oval or round basal nuclei and poorly differentiated large digestive cells. The cytoplasm of the digestive cells is filled with inclusions of various types and sizes. The epithelium is surrounded by thin muscle fibres and connective tissue. The rectal sac is connected to the anal opening by a short, narrow anal canal. Histologically, the rectal sac is composed of flattened epithelial cells with large nuclei, and their cytoplasm contains several inclusions. They are surrounded by epithelial muscle fibres and thin connective tissue (El Shoura et al., 1984).

In a study, the ultrastructure of the midgut of female ticks of *A. cajennense* was examined according to nutritional status. Depending on the diet, the midgut contains an outer muscle layer of varying thickness, the basal lamina changes, the epithelium consists of digestive and generative cells arranged in a single row, and mitochondria and changes in organelles such as the Golgi complex and inclusions such as lipid droplets have been reported (Caperucci et al., 2010).

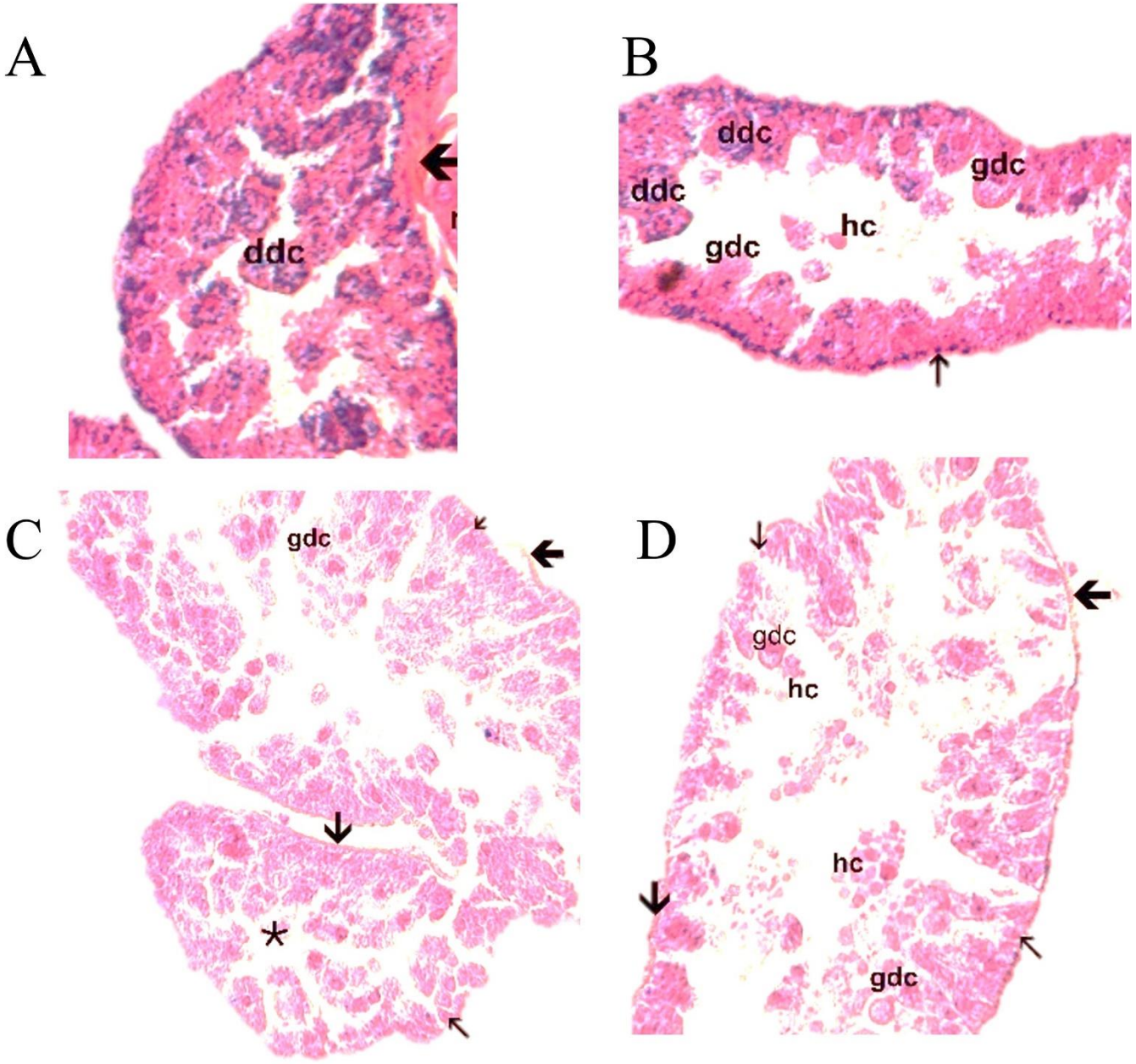

Figure 2. Histology of the digestive tract of the midgut of *Rhipicephalus bursa*. ←: muscle layer, ✶: caecae, ←: stem (generative) cell, gdc: granular digestive cell, ddc: densely granulated digestive cell. X400, H&E.

Agyei and Runham (1995) studied the cell types and changes in these cells in the midguts of *R. microplus* and *R. appendiculatus* during their blood feeding period. They found that there are two types of cells in the midgut of both species, digestive and non-digestive. They found that the non-digestive cells of *R. appendiculatus* were more clearly cylindrical, while the same type of cells of *R. microplus* were cubic. They also noted that the midgut epithelium of the ticks in question is composed of stem cells located in the basement membrane, digestive cells and secretory cells that dominate the epithelium and have different appearances at different stages of feeding.

According to Alberti and Coons (1999), the tick midgut is divided into two parts, the anterior and postventricular regions, and is lined with a simple pseudomultilayered epithelium. They identified six different cell types in the epithelium: stem cell, digestive cell, endocrine cell, secretory cell, vitellogenin cell and unspecified cell.

The midgut of male and female *Rhipicephalus sanguineus* was examined at different stages of digestion. In this study, it was reported that the muscle layer around the midgut was slightly thinner in males than in females. It has been reported that the midgut epithelium is pseudostratified cuboidal or cylindrical and contains two types of cells: stem cells and digestive cells, with digestive cells exhibiting different characteristics at different stages of feeding (Remedio et al., 2013).

In the current study, it was observed that the epitheliums in the midguts of *R. bursa* and *R. turanicus* species consists of pseudostratified cuboidal or cylindrical cells surrounded by a thin muscular layer. One of the cells in the epithelium is a stem or generative cell and the other is a digestive cell, which has different morphologies depending on the digestive status. These results show that the midgut epithelium of *R. bursa* and *R. turanicus* species shares some characteristics with other studies in

the literature. The fact that there are fewer densely granulated cells in the midgut epithelium of *R. bursa* may reflect the feeding period of the tick. However, further studies are needed to specifically investigate the types of digestive cells.

Authors' contributions

Filiz Demir: Conceptualization, investigation, resources, methodology, writing-original draft, supervision, visualisation, writing – review and editing. **Neşe Karabay:** Investigation, resources, visualisation. **Beyza Albayrak:** Investigation, resources, visualisation. **Sümeyye Arslan:** Investigation, resources, visualisation. **Adem Keskin:** Conceptualization, investigation, supervision, writing – review and editing.

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RESEARCH ARTICLE

A new species of the genus *Favognathus* Luxton (Acariformes: Cryptognathidae) from Afyonkarahisar province, Türkiye

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ABSTRACT: A new species is described and illustrated based on adult females viz. *Favognathus concavum* sp. nov., collected from soil and litter under *Prunus spinosa* (Rosaceae) in Afyonkarahisar province, Türkiye. This new species differs from all known *Favognathus* species in that its prosternal apron is concave-shaped. A key is provided to the species of the genus *Favognathus* from Türkiye.

Keywords: Acari, description, species key, Raphignathoidea, *Favognathus concavum* sp. nov.
Zoobank: https://zoobank.org/C0E38205-4505-45D1-9473-944B729EAFBD

INTRODUCTION

Mites of the family Cryptognathidae Oudemans, 1902 are known as predators, sometimes in association with insects and microphytophages in edaphic habitats, moss covered substrates, leaf litter, bark, lichens (Luxton, 1973; Fan and Zhang, 2005; Mohammad Doustaresharaf et al., 2019).

The cryptognathid mite species are generally distinguished on the basis of their body ornamentation and morphology of the prodorsal hood and prosternal apron more than similar palp and leg setal counts (Luxton, 1973; Khanjani et al., 2014). The family Cryptognathidae (Acari: Raphignathoidea) contains 71 species in three valid genera: *Favognathus* Luxton (46 species), *Cryptognathus* Kramer (23 species) and *Cryptofavognathus* Doğan and Dönel (2 species) (Beron, 2020; Akyol, 2021).

Until now, 14 species of *Favognathus* have been recorded from Turkey (Akyol, 2021). In this paper, a new species, *Favognathus concavum* sp. nov., is described and illustrated based on adult females. Key to the species of the genus *Favognathus* from Türkiye is provided based on adult females.

MATERIALS AND METHODS

The specimens were collected from soil and litter under *Prunus spinosa* (Rosaceae) Afyonkarahisar province, Türkiye, and brought to the laboratory in plastic bags and extracted by Berlese-Tullgren funnels for 7 days. Mites were collected in 70% ethanol and mounted on slides in modified Hoyer's medium. The mite specimens were drawn and measured under two research microscopes (Nikon Eclipse E 400 with a drawing attachment and Olympus CX21 with an ocular micrometer). The setal nomenclature follows those of Grandjean (1944) and Kethley (1990). The holotype measurements were given first and followed by range of measurements of paratypes in parentheses. Measurements of legs were taken from the base of the trochanter to the tips of the tarsal claws. All measurements were given in micrometers (μm). The specimens, mounted on slides, are deposited in CBZM, see Zhang (2018) for the abbreviation.

RESULTS AND DISCUSSION

Family Cryptognathidae Oudemans, 1902

Genus *Favognathus* Luxton, 1987

Type species. *Cryptognathus cucurbita* Berlese, 1916, by original designation (Luxton, 1987).

***Favognathus concavum* sp. nov.** (Figures 1 and 2)

Zoobank: https://zoobank.org/48BF30F9-B717-44F3-8058-C3C98D59C9CA

Diagnosis

Anterior margin of hood smooth with 4 or 5 weak visible dimples in each longitudinal row; prosternal apron concave-shaped and with 9 foveolae; dorsal shield has two pairs clusters of five larger pits (between setae *c*, *d* and anterior of setae e_1), one pair of spine-like processes (front of setae *f*); ventral shield has two pairs spine-like processes (opposite setae 2*c*), two pairs clusters of five larger pits (posterolateral of legs IV); tarsi 15(+1*φρ* +1*ω*)-12(+1*φρ* +1*ω*)-9(+1*ω*)-9(+1*ω*); setae *tc* on tarsus II dissimilar.

Description: Female (n=6)

Length of body (excluding gnathosoma) 325 (325-351), width 224 (221-239).

Gnathosoma (Figs 1C, 2E). Gnathosoma extrudable from under hood. Length of gnathosoma (including palps) 364 (333-351); subcapitulum 117 (130); palp 104 (104-109); chelicera 117 (117-130). Subcapitulum with a pair of long setae *m* 34 (31-34) and 2 pairs of rostral setae, or_{1-2} 13 (13). Palpal supracoxal setae (*ep*) small and weakly clavate. Palp trochanter without seta, palp femur with three

setae (*d*, *l'*, *v''*), palp genu with two setae (*d*, *l''*), palp tibia with three setae (*d*, *l'*, *l''*), palp tarsus with four eupathidia (*acmς*, *ul'ς*, *ul''ς*, *sulς*), four simple setae (*ba*, *bp*, *va*, *lp*) and one solenidion *ω* 3(3).

Dorsum of idiosoma (Fig. 1A). Anterior margin of hood smooth with 4 or 5 weak visible dimples in each longitudinal row. One pair of eyes and one pair of postocular bodies laterally between setae *sci* and *sce*. Dorsal shield with light and small punctated reticulations in lateral, and with dense and large punctations in median, two pairs of slit-like cupules (*ia*, *im*), two pairs clusters with five large pits (between setae c_1 and *d*, lateral to setae e_1) and one pairs of the spine-like process (anterior to setae *f*) present. Dorsal shield with 11 pairs of simple setae.

Lengths and distances of dorsal setae as follows: *vi* 21 (21), *ve* 31 (31), *sci* 31 (27-31), *sce* 31 (31-34), *c* 36 (34-36), *d* 34 (34), e_1 34 (34), e_2 34 (34-36), *f* 34 (34-36), h_1 34 (34), h_2 27 (26-27), *vi–vi* 34 (34-36), *vi–ve* 16 (16), *ve–ve* 39 (34-39), *ve–sci* 10 (9-10), *sci–sci* 57 (49-57), *sci–sce* 27 (27-31), *sce–sce* 107 (101-107), *sce–c* 16 (16), *c–c* 75 (73-75), *c–d* 55 (52-55), *d–d* 117 (114-117), *d–*e_1 18 (18-21), e_1–e_1 83 (78-86), e_1–e_2 18 (18-21), e_2–e_2 109 (109), e_1–*f* 47 (47-52), *f–f* 34 (34-34), *f*–h_1 34 (27-34), h_1–h_1 18 (18-21), h_1–h_2 31 (31), h_2–h_2 78 (78-83).

Venter of idiosoma (Fig. 1B). Prosternal apron concave-shaped and with 9 foveolae. Ventral shield with pores, has two pairs spine-like process (opposite to setae 2*c*), two pairs of clusters with five large pits (posterior of the legs IV). Ventral seta smooth, lengths: 1*a* 18 (16-18), 3*a* 10 (10-13), 4*a* 10 (10-13. aggenital setae ag_1 10 (10-13), ag_2 10 (10-13) and genital shield with two pairs of setae g_1 13 (13-16), g_2 13 (13-16) adjacent to genital opening. Coxal setae 3*b* thicker than other coxal setae. Anal shield with three pairs of setae ps_1 16 (16-18), ps_2 13 (13-16), ps_3 10 (10-13).

Legs (Figs 2A-D). Length of legs (from base of trochanter to tip of tarsal claw): leg I 226 (224-242), leg II 172 (172-192), leg III 182 (182-192), leg IV 216 (213-218). Leg I setation (Fig. 2A): Tr 1 (*v'*), Fe 4 (*d, l', l'', bv''*), Ge 5(1) (*dp*, *l'*, *l''*, *v'*, *v''*, *κ*, Ti 5(2) (*dp*, *l'*, *l''*, *v'*, *v''*, *φ*, *φp*), Ta 15(2) (*ft'*, *ft''*, *tc'ς*, *tc''ς*, *p'ς*, *p''ς*, *a'*, *a''*, *u'*, *u''*, *v'ς*, v''ς, *pv'*, *pv''*, *pl'*, *ω*, *φp*). Tarsus I solenidion *ω* 13 (13); solenidion *φp* 16 (16); tibia I solenidion *φ* 9 (9-10); solenidion *φp* 18 (16-18); genu I famulus *κ* 5 (5). Leg II setation (Fig. 2B): Tr 1 (*v'*), Fe 2 (*d*, *l'*, *bv''*), Ge 4(1) (*d*, *l'*, *l''*, *v'*, *κ*), Ti 5(1) (*d*, *l'*, *l''*, *v'*, *v''*, *φp*), Ta 12(2) (*bv'*, *bl'*, *bl''*, *tc'ς*, *tc''ς*, *p'ς*, *p''ς*, *a'*, *a''*, *u'*, *u''*, *v'ς*, *ω*, *φp*). Tarsus II solenidion *ω* 10 (9-10); solenidion *φp* 9 (9) attenuated, setae *tc* dissimilar; tibia II solenidion *φp* 13 (10-13); famulus *κ* 5 (5). Leg III setation (Fig. 2C): Tr 2 (*l'*, *v'*), Fe 2 (*d*, *ev'*), Ge 2 (*dp*, *v'*), Ti 4(1) (*dp*, *l''*, *v'*, *v''*, *φp*), Ta 9(1) (*bv'*, *tc'ς*, *tc''ς*, *p'ς*, *p''ς*, *a'*, *a''*, *u'*, *u''*, *ω*); solenidion *ω* 5 (5); *φp* 13 (13). Leg IV setation (Fig. 2D): Tr 1 (*v'*), Fe 2 (*d*, *ev'*), Ge 3 (*dp*, *l''*, *v'*), Ti 3 (*dp*, *v'*, *v''*), Ta 9(1) (*bv'*, *tc'ς*, *tc''ς*, *p'ς*, *p''ς*, *a'*, *a''*, *u'*, *u''*, *ω*). Solenidion *ω* 10 (10). All setae simple setae smooth, solenidion (*ω*) on tarsi I-IV baculiform, solenidia *φ* and *φp* on tibiae I-III attenuated and famulus *κ* on genua I-II slightly bulbous at tip.

Male and immature stages: Unknown.

Etymology

The name of this new species is derived from Latin '*concavum*' meaning "*concave*" and refers to the prosternal apron concave-shaped.

Type materials

Holotype female and five paratype females from litter and soil under *Prunus spinosa* (Rosaceae) 1350 m a.s.l., Emirdağı mountains, B. Karabağ village, Bolvadin district, Afyonkarahisar province, Türkiye, 16 May 2015; coll. M. Akyol.

Favognathus concavum sp. nov. resembles *F. karabagiensis* Akyol, *F. cucurbita* (Berlese) and *F. acaciae* Doğan and Ayyıldız in that the dorsal and ventral shield is partly reticulated laterally, anterior margin of hood smooth, dorsum without rosette patterns and addorsal setae *tc* on tarsi II dissimilar (Luxton and Lee, 1969; Doğan and Ayyıldız, 2004; Akyol, 2021). However, it can be easily differentiated from them by the following characters: (1) prosternal apron concave-shaped in the new species, whereas prosternal apron wedge-shaped in *F. karabagiensis*, *F. cucurbita* and *F. acaciae*, (2) dorsal shield with clusters with five large pits and one pairs of spine-like process, venter with two pairs of the clusters with five large pits and two pairs of spine-like process in the new species opposed to dorsal shield with clusters of five pairs of five-six spine-like processes and venter with clusters of five pairs of three-four spine-like processes in *F. karabagiensis*, these are absent in *F. cucurbita* and *F. acaciae*, (3) prosternal apron with 9 faveolae versus 19 in *F. karabagiensis*, 17 in *F. cucurbita* and 14 in *F. acaciae*, (4) tarsus I 15(+1*φρ* +1ω) in the new species, instead, 14(+1*φρ* +1*ω*) in *F. cucurbita* and *F. acaciae*, (5) tarsus II 12(+1*φρ* +1ω) in the new species, instead, 11(+1*φρ* +1*ω*) in *F. cucurbita* and *F. karabagiensis*.

Key to the Turkish species of the genus *Favognathus* (modified from Akyol, 2021).

1a. Genu II with famulus *κ* 3

1b. Genu II without famulus *κ* 2

2a. Genu I with famulus *κ*, genu IV with two setae ..... *F. luxtoni*

2b. Genu I without famulus κ, genu IV with three setae ..... *F. erzurumensis*

3a. Anterior margin of hood smooth or rough 4

3b. Anterior margin of hood denticulate ..... *F. izmirensis*

4a. Dorsal shield partly or completely reticulated 6

4b. Dorsal shield without reticulations, completely punctated 5

5a. Ventral shield partly reticulated ..... *F. dakotaensis*

5b. Ventral shield without reticulations ..... *F. kamili*

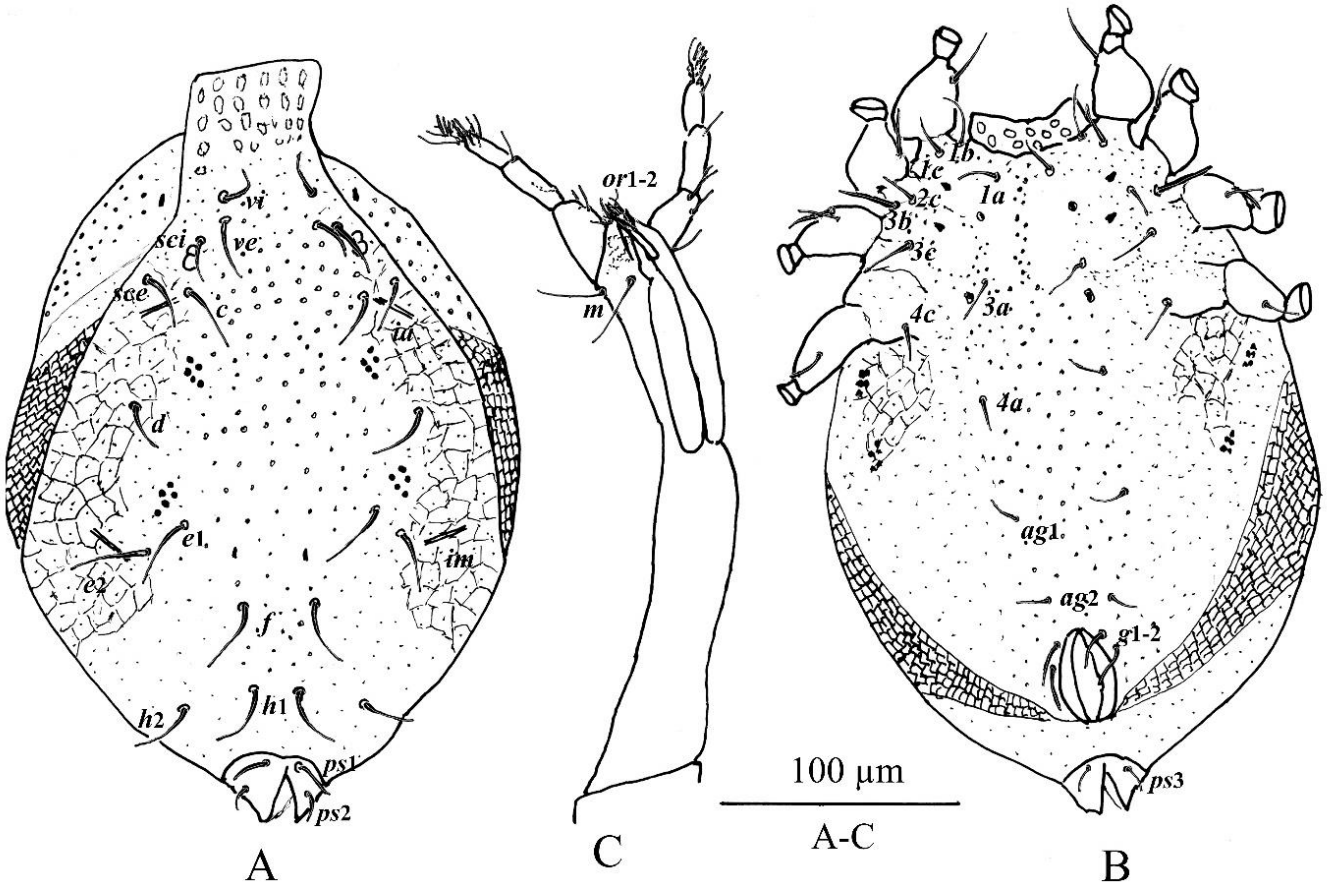

Figure 1. *Favognathus concavum* sp. nov. (female). **A.** Dorsal view of idiosoma, **B.** Ventral view of idiosoma, **C.** Gnathosoma.

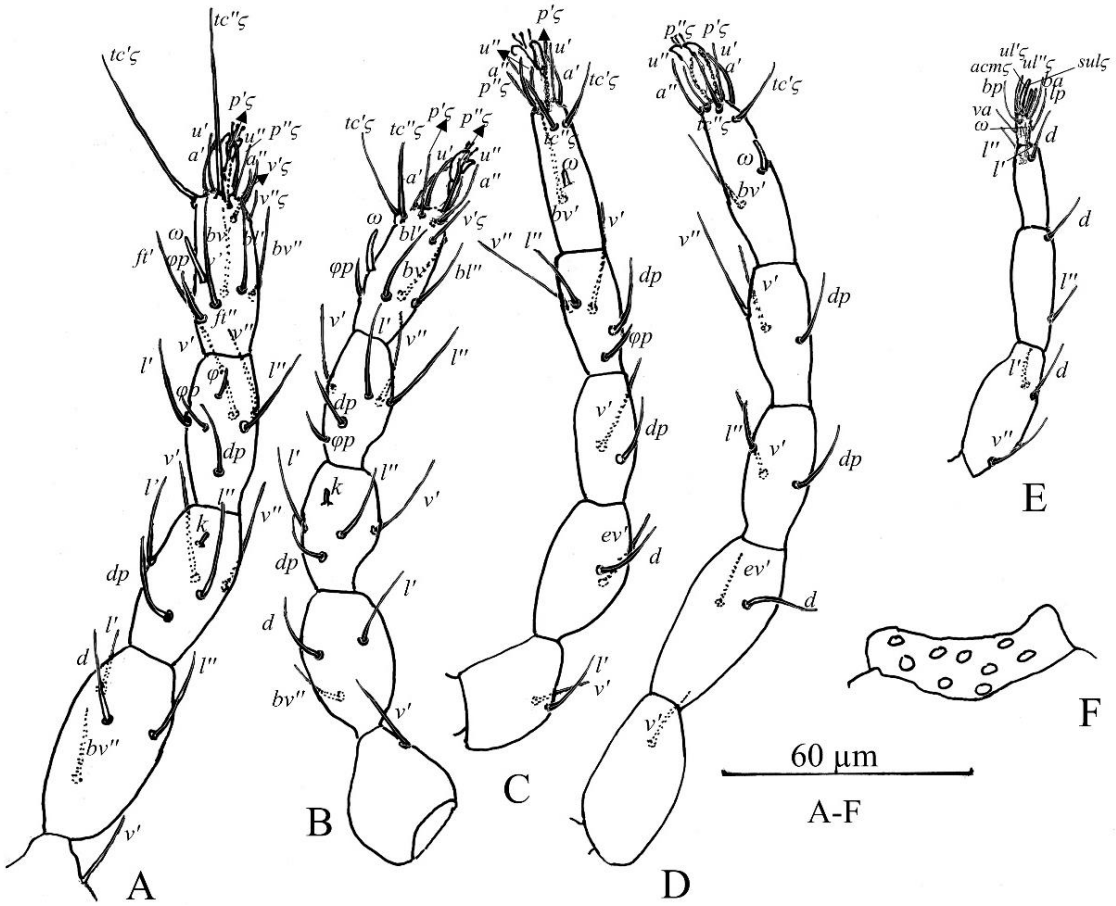

Figure 2. *Favognathus concavum* sp. nov. (female). **A.** Leg I, **B.** Leg II, **C.** Leg III, **D.** Leg IV, **E.** Palp, **F.** Prosternal apron.

6a. Dorsal shield partly reticulated 7

6b. Dorsal shield completely reticulated 12

7a. Dorsum with rosette patterns 8

7b. Dorsum without rosette patterns 9

8a. Femur II with two setae.....*F. turcicus*

8b. Femur II with three setae .....*F. amygdalus*

9a. Dorsal shield with clusters of strong pits or spine-like processes 10

9b. Dorsal shield without clusters of strong pits or spine-like processes 11

10a. Dorsal shield with clusters of five pairs of five-six spine-like processes, prosternal apron wedge-shaped ....*F. karabagiensis*

10b. Dorsal shield with clusters of two pairs of five strong pits, prosternal apron concave-shaped ....*F. concavum* sp. nov.

11a. Prosternal apron with 14 dimples .....*F. acaciae*

11b. Prosternal apron with 17 dimples.....*F. cucurbita*

12a. Dorsum with two pairs of rosette patterns.....13

12b. Dorsum with one pair of rosette patterns. *F. rosulatus*

13a. Setal formula of tarsi 16–12–10–10, hood with 5-6 dimples in each longitudinal row, prosternal apron with 11 faveolae .....*F. bafranus*

13b. Setal formula of tarsi 17–14–10–10, hood with 6-8 dimples in each longitudinal row, prosternal apron with 12-17 faveolae 14

14a. Dorsal body completely punctated and striated..... .....*F. manisaensis*

14b. Dorsal body partly punctated and without striae ....*F. distortus*

Statement of ethics approval

Not applicable.

Conflict of interest

The author declares no conflict of interest.

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RESEARCH ARTICLE

Two new records of the genus *Macrocheles* (Acari: Macrochelidae) from Türkiye, with redescription of *M. similis* Krantz and Filipponi

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ABSTRACT: The present work deals with two species of the genus *Macrochles*, namely *Macrocheles similis* and *Macrocheles mammifer*. These species were found as photretics on a beetle (*Pentadon* sp.) in Antalya and some specimens of *M. similis* were collected freely in Erzincan, Türkiye. *M. similis* was originally described and illustrated from Australian specimens and subsequently reported from several regions, including the USA, Japan and the Hawaiian Islands. Now, unexpectedly, the species has been recorded for the first time in the Western Palearctic. This species is morphologically very similar to *Macrocheles muscaedomestiae*, making it very difficult to distinguish them from each other based on morphological characteristics. Therefore, *M. similis* may have been misidentified as *M. muscaedomesticae* in this region. The make correct identification of *M. similis* is described again in detail here and compared with *M. musacaedomesticae*. In addition, both species investigated in this study are new additions to the Turkish mite fauna.

Keywords: Mesostigmata, mite, phoretic, species diversity, Antalya, Erzincan
Zoobank: https://zoobank.org/217F96BE-DCBA-4CA9-BDC0-BC9F409892F7

INTRODUCTION

In Türkiye, taxonomic work on the family Macrochelidae is mainly concentrated in the northeastern part of the country, and knowledge of species diversity in other parts of the country is quite limited. So far, a total of 35 species of Macrochelidae mites have been recorded in Türkiye (Özbek, 2017), and most of these species have been found in soil and organic material, with some exceptions. For instance, *M. muscaedomesticae*, found on houseflies and ground squirrels (Göksu and Güler, 1968; Çiçek et al., 2008), while *M. glaber* (Müller, 1860) and *Neopodocinum caputmedusae* (Berlese, 1908) found on dung beetles (Çobanoğlu and Kırgız, 2001). Additionally, *M. similis* and *M. mammifer* are present on a beetle of the genus *Pentodon*, which benongs to the subfamily Dynastinae (Fig. 1). The genus *Macrocheles* is represented by fifteen species in Türkiye (including the present work). One of these species was described from the province of Tokat by Özbek (2017).

The genus *Macrocheles* is one of the largest cosmopolitan genera within the family Macrochelidae, with more than three hundred described valid species in the world (Emberson, 2010). The species of this large genus are morphologically uniform, so it is not easy to distinguish them clearly. The most useful feature is the ornamentation on the ventral shields, especially those on the sternal shield (Hyatt and Emberson, 1988; Halliday, 2000; Mašán, 2003). In recent years, some morphologically similar, litter-dwelling and non-phoretic species have been separated from this genus, such as *Macrholaspis* Oudemans, 1931, *Nothrholaspis* Berlese, 1918 (Mašán, 2003; Emberson, 2010; Krantz, 2018), but there are some species that are close to these separate genera, such as *Macrocheles niksarensis*, that have some characters that fit the genus *Nothrholaspis* and some that fit the genus *Macrocheles*, making it very difficult to draw a clear boundary between species. With *Macrocheles* and the related genera *Nothrholaspis* and *Macrocholaspis* there are problems and differences of opinion with regard to certain species. These problems arise primarily from the classification of genera on the basis of morphological characteristics. However, with additional knowledge of non-morphological features, this problem could easily be solved. For example, although *M. similis* and *M. muscaedomesticae* have minor morphological differences, there appear to be two significant biological differences between them, such as host specificity and reproductive strategy (Halliday, 1990).

MATERIALS AND METHODS

The mites were collected in Aziz Sancar Park in Antalya and in Ekşisu Marsh in Erzincan, Türkiye. Some specimens were caught by hand and then placed in a small container with 70% ethanol, while others were collected while sieving cattle dung, litter and moss using a modified Berlese funnel. All mites were mounted in Hoyer's medium according to the methods of Walter and Krantz (2009). The mite preparations and host were examined, imaged, photographed, and measured using an Olympus BX63 upright microscope with DP73 camera and a Nikon SMZ25 stereomicroscope with DS-Ri2 camera. All measurements are given in micrometres (µm). The terminology of dorsal setae used in this paper follows that of Lindquist and Evans (1965) as applied to the Macrochelidae by Halliday (1986, 1987). The specimens are kept at EBYU (Acarological Laboratory of Erzincan Binali Yıldırım University, Erzincan, Türkiye).

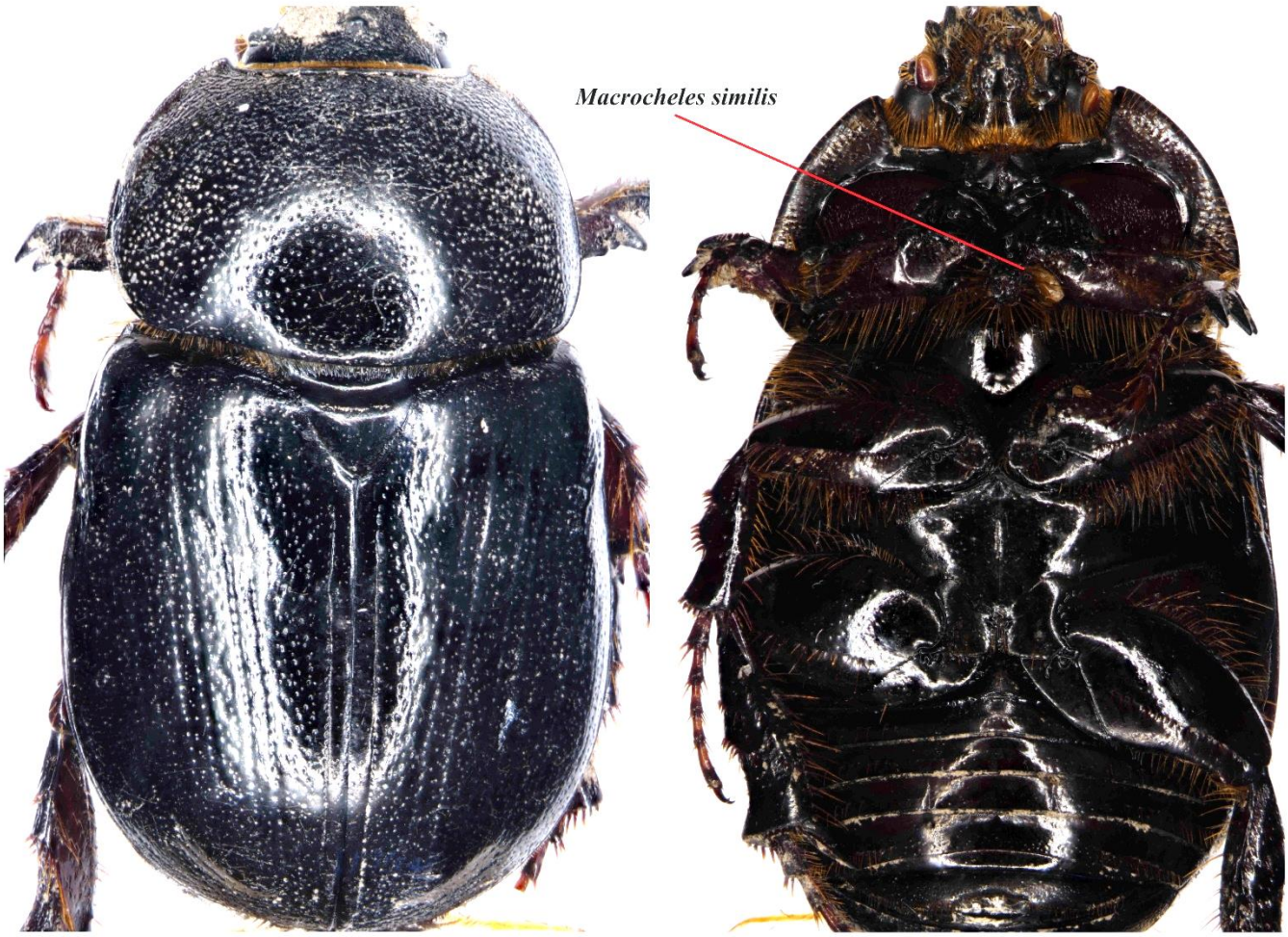


Figure 1. Host of the mites (*Pentadon* sp.). Dorsal view and ventral view with *Macrocheles similis*.

RESULTS

Macrocheles mammifer Berlese, 1938

Macrocheles (*Nothrholaspis*) *mammifer* Berlese, 1918: 171.

Macrocheles (*Macrocheles*) *postneri* Krauss, 1970: 28.

Macrocheles mammifer – Krantz, 1967: 150; Bregetova, 1977: 365; Halliday, 2000: 301; Mašán, 2003: 93.

Specimens examined. 2 ♀♀, Aziz Sancar Park, Antalya, Türkiye, 18 May 2018, phoretic on *Pentadon* sp. (Dynastinae).

Notes. *Macrocheles mammifer* is easily distinguished from other members of the genus *Macrocheles* by its characteristic dorsal chaetotaxy with the smooth and pointed dorsal setae *j2*, *j5*, *j6*, *z1*, *z5*, *z6*, *s2*, *s6*, *r4*, the others being pilose. The dorsal shield of the Turkish specimens is 880-902 long and 590-600 wide at its widest point. There are no significant morphological differences between the Turkish and the previously known specimens (Krantz, 1967; Bregetova, 1977; Halliday, 2000; Mašán, 2003). The dorsal and ventral views of the species are shown in Figures 2 and 3. This species is distributed worldwide (Mašán, 2003) and is recorded for the first time from Türkiye in this work.

Macrocheles similis Krantz and Filipponi, 1964

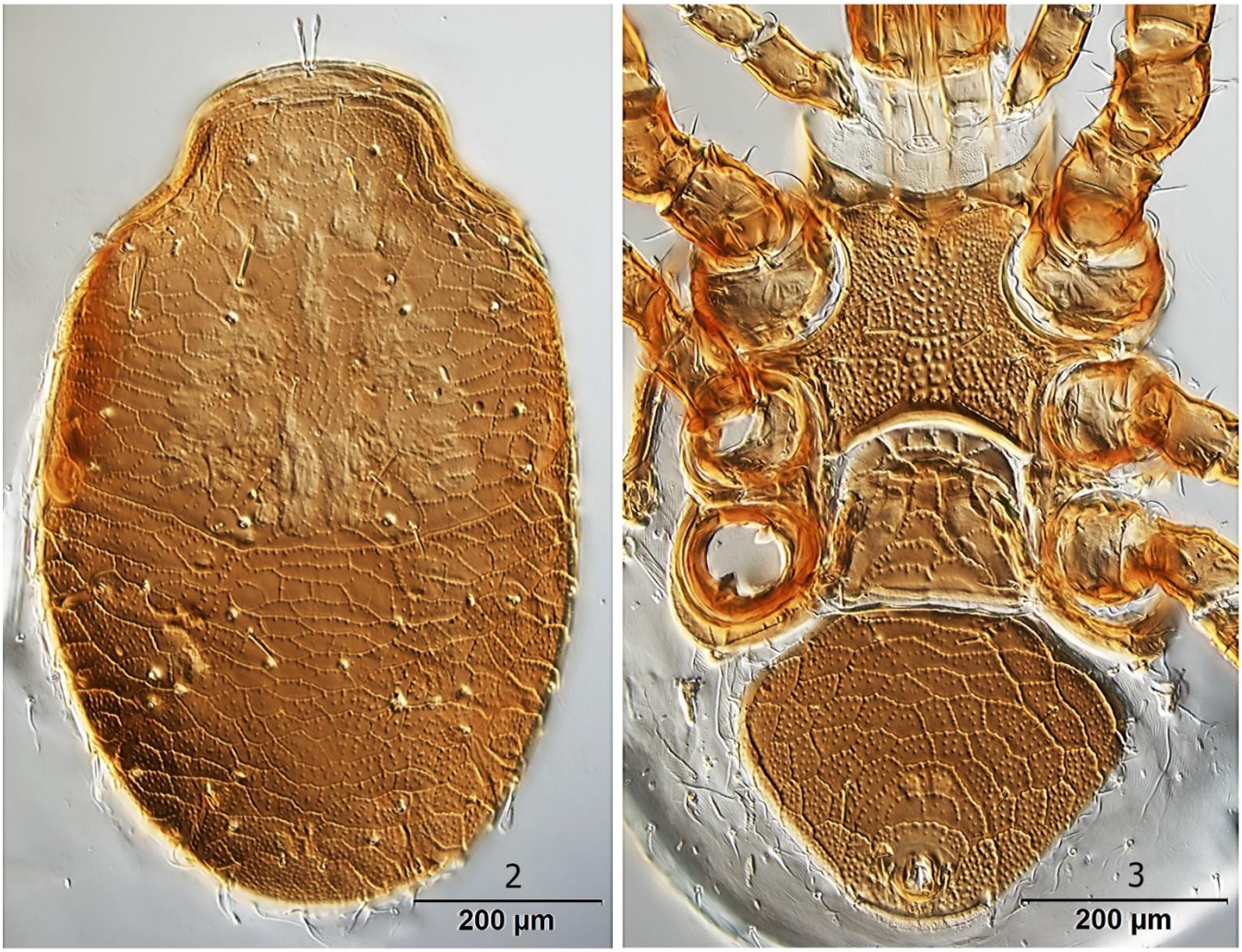
Macrocheles similis Krantz and Filipponi, 1964: 37.

Macrocheles similis – Rodriguez and Ibarra, 1967: 809; Tenorio et al., 1985: 301; Halliday, 1990: 422; 2000: 311; Manning and Halliday, 1994: 91; Saito and Takaku, 2013: 37; Ji et al., 2023: 79 (misidentification).

Diagnosis. Dorsal shield less than 1000, with 28 pairs of setae; *z1*, *j5*, *j6*, *z5*, *z6*, and *J2* smooth, other setae more or less pilose, sometimes knife-like; *linea media transversa* distinct, *linea obliquae anterior* connected with *linea arcuate*, distinct *linea angulate*; ventrianal shield broader, length/width =0.92-0.99, deutosternal furrow with 4-6 rows of denticles; anterior tips of peritremes extend beyond bases of setae *z1*; thelytokous parthenogenesis; phoretic in beetles.

Description.

Dorsum (Fig. 4). Dorsal shield elongate, 800–900 long, 490–580 wide at widest point (n=9), reticulate with polygonal punctation pattern (Fig. 12), with 28 pairs of setae; setae *j5*, *j6*, *z1*, *z5*, *z6*, and *J2* smooth and pointed, *j1* and *Z4* distinctly pilose and brush-like, other dorsal setae mostly distally on slightly pilose or knife-like, especially marginally situated setae pilosity more distinct and



Figures 2-3. *Macrocheles mammifer* (female). **1.** Dorsal view, **2.** Ventral view.

reduced pilosity toward paraxial position, distally a few denticles or entirely knife-like (Figs 5, 18, 19); setae *j1* 42–46, *z1* 20–25, *j6* 35–42, *J5* 25–30, other setae length 40–65.

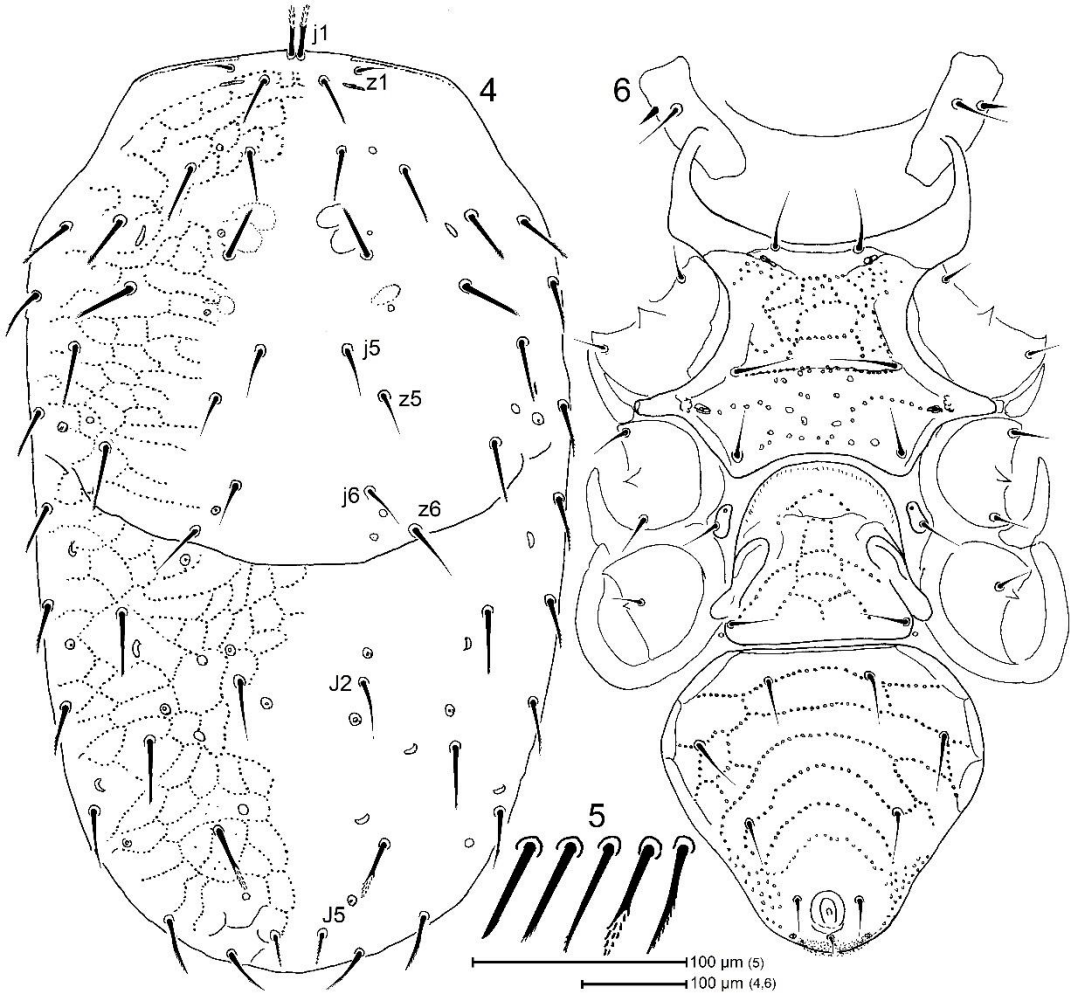
Venter (Figs 6, 13). Sternal shield 180-210 long, 150-190 wide in middle of coxae II; surface sculptured with reticulate pattern and punctation and provided with three pairs of needle-like setae and two pairs of pores; *st1* and *st2* almost equal in length (54–58), *st3* 40-46 long; its surface with distinct *linea media transversa*, *line obliquae anterior* connected with *linea arcuate*, distinct *linea angulate*; area between *st2* and *st3* ornamented with well-sculpted large oval patterns. Metasternal shields free, elliptical, each with a pore and a smooth seta *st4* (34–40). Epigynal shield 160–180 long, 165–195 wide, helmet-shaped, ornamented with punctate reticulation, with a pair of smooth setae *st5* (42-48). Ventrianal shield wider than long, 260–310 long, 280–325 greatest width (L/W =0.92–0.99), ornamented with polygonal punctate pattern, with three pairs of smooth pre-anal setae (40-48), one pair of long para-anal setae, and one postanal seta. Anterolateral extensions of cribrum not reaching bases of para-anal setae. Anterior tips of peritremes reaching beyond bases of setae *z1*.

Spermathecal structure. As in Figure 7.

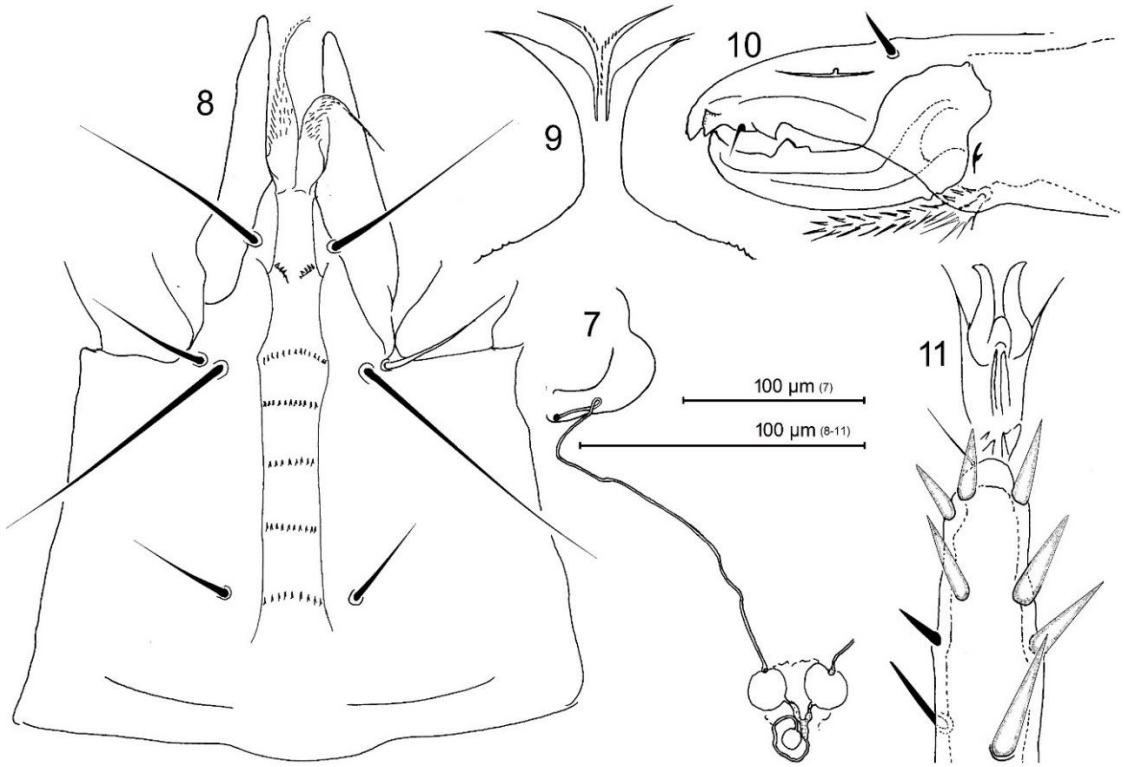
Gnathosoma. Setae *h3* longest, *h2* almost subequal in length to *pc*, *h1* longer than *h2*. Corniculi long and horn-like. Deutosternal furrow with six rows of denticles, row between setae *h1* separated into two parts (Fig. 8). Epistome with a pair of lateral processes distally, a median process deeply bifurcated distally, with long spines on its stem (Fig. 9). Chelicerae well developed, movable digit about 97 long, with two median teeth and unidentate terminal hook, fixed digit about 75 long to level of base of dorsal seta, with one distinct median tooth, one distal tooth near unidentate terminal hook, distinct pilus dentilis and a smooth dorsal seta. Two arthrodial brushes are present, one very short and another more than half as long as movable digit (Figs 10, 16, 17).

Legs. Chaetotaxy typical for the genus and family (Evans, 1963). All coxae with smooth and pointed setae. Tarsus II as in Figure 11.

Specimens examined. 21 ♀♀, Aziz Sancar Park, Antalya, Türkiye, 18 May 2018, phoretic on a dung beetle. Following specimens from Erzincan Ekşisu Marsh, Türkiye 1150 m a.s.l.: one ♀, 39°43'31.91"N 39°37'20.64"E, 13 April 2013, in moss; 4 ♀♀, 39°42'38.65"N 39°36'5.18"E, 13 May 2013, dung and



Figures 4-6. *Macrocheles similis* (female). **4.** Dorsal shield, **5.** Variations of dorsal setae, **6.** Ventral shields.



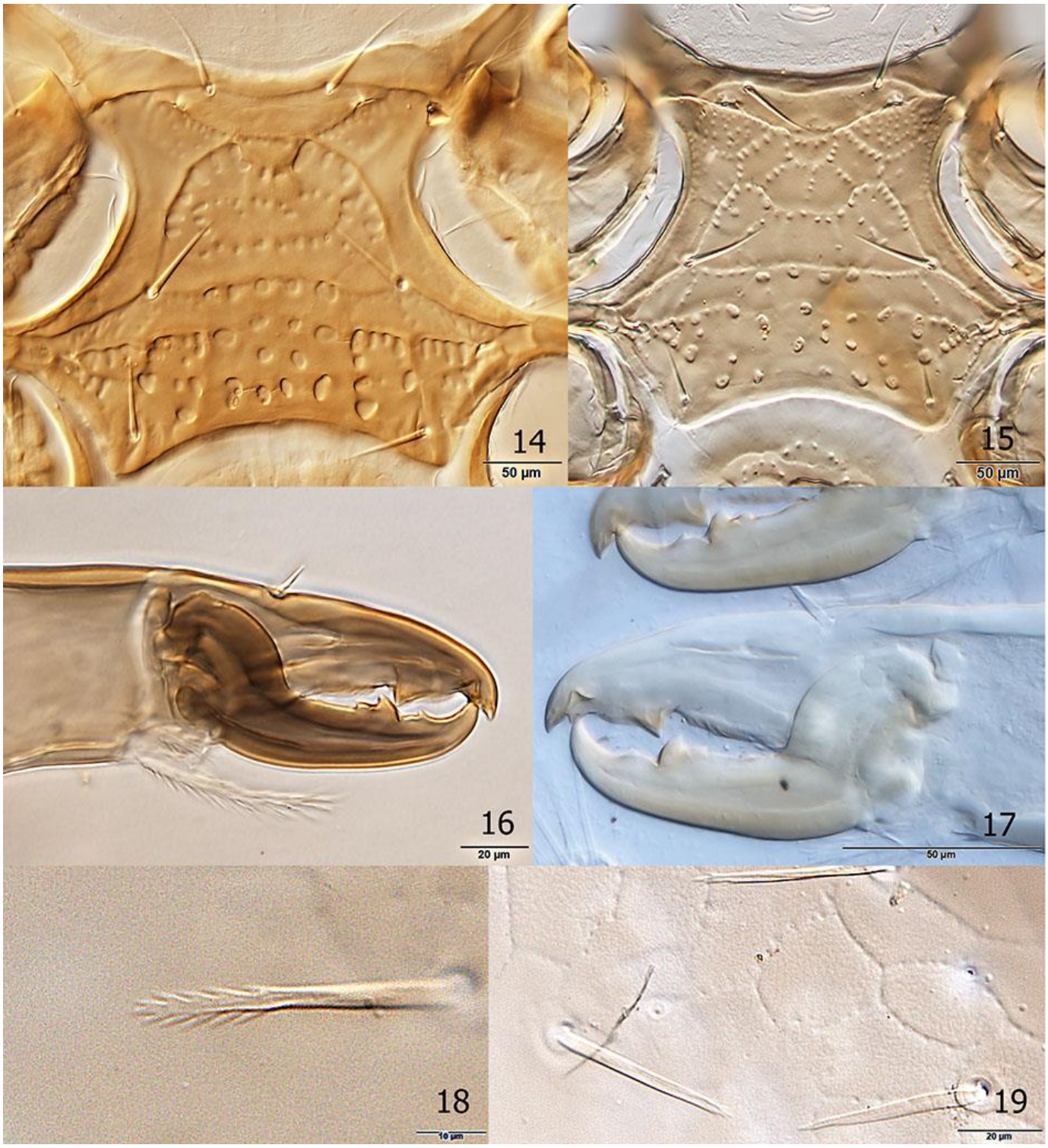
Figures 7-11. *Macrocheles similis* (female). **7.** Spermathecal structure, **8.** Gnathosoma, **9.** Epistome, **10.** Chelicera, **11.** Tarsus II.

Figures 12-13. *Macrocheles similis* (female). **12.** Dorsal view, **13.** Ventral view.

moss in *Juncus heldreichianus*; 4 ♀♀, 39°43'53.4"N 39°37'02.8"E, 16 June 2013, soil and moss; one ♀, 39°43'41.1"N 39°37'30.2"E, 04 July 2013, dung and moss; 7 ♀♀, 39°43'53.4"N 39°37'03.0"E, 02 August 2013, dung and moss; one ♀, 39°43'59.7"N 39°37'15.3"E, 25 October 2013, in dung; 4 ♀♀, 39°43'34"N 39°37'24"E, 11 November 2013, in moss.

Notes. Macrochles similis was first described by Krantz and Filipponi (1964) and illustrated by a single female specimen in the Australian region. Later, Rodriguez and Ibarra (1967) mentioned the species in an ecological study of mites on sheep and cattle pastures in Kentucky, USA, and Tenorio et al. (1985) reported the occurrence of this species in the Hawaiian Islands, and Halliday (1990) redescribed the mature and immature stages of numerous Australian specimens and provided further details on morphology and biology. Saito and Takaku (2013) investigated the degree of predatory ability of this species on *Tyrophagus similis* Volgin in Japan. Finally, Ji et al. (2023) reported this species from Korea, but it is not a specimen of *M. similis* as it is shown in the photo of the ventral side.

Macrochles similis morphologically most resembles *M. muscaedomesticae*, Krantz and Filipponi (1964) distinguished it based on some characters such as the pilosity of the dorsal setae, the dimension of the body shields, and the number of rows on the deutosternal furrow of the gnathosoma, but their study revealed only single specimens, later Halliday (1990) updated all characters based on the many specimens. Halliday (1990) shows that these separating characters are unreliable, except for the dimensions of the body part. We here confirmed the statement made by Halliday (1990) based on the Turkish specimens. Krantz and Filloponi (1964) state that setae *j2*, *j3*, *z2*, *z4*, *r3*, *s4*, *r4*, *s2*, *s5*, *s6*, *S1*, *S2*, *Z1* are simple, but Halliday (1990) reported that most of them may have pilosity, especially *r3*, *S1*, *S2* and *Z1* may be more pronounced. Specimens in Türkiye, setae *j5*, *j6*, *z1*, *z5*, *z6*, and *J2* smooth, *j1* and *Z4* strongly pilose and brushy (Fig. 18), other dorsal setae mostly distal on slightly pilose or knife-like, especially marginally situated setae more distinctly pilose. Krantz and Filopponi (1964) state that the deuterosternal furrow has four rows of denticles, Halliday (1990) states that it has five rows of denticles, except for one specimen which has four, a female specimen which has six rows of denticles.



Figures 14-19. *Macrocheles* spp. (females). **14.** Surface of sternal shield of *M. muscaedomesticae*. **15-19.** *M. similis*. **15.** Surface of sternal shield, **16-17.** Chelicera, **18.** Seta Z4, **19.** Some setae on dorsal shield.

All specimens examined in the current study have are six rows of denticles, the row between setae *h1* is divided into two parts. The body size and the ornamentation on the sternal shield (surface of the sternal shield in *M. muscaedomesticae* as in Figure 14 and in *M. similis* as in Figure 15) are the most reliable differences between *M. muscaedomesticae* and *M. similis*. The length of dorsal shield of *M. similis* is 750-881 in Australian specimens (Krantz and Fillipponi, 1964; Halliday, 1990), 800-900 in Turkish specimens. Özbek et al. (2015) also report a length of more than 1000 for *M. muscaedomesticae*, which was found in the dung of one specimen.

In addition, Halliday (1990) notes that non-morphological differences between *M. similis* and *M. muscaedomesticae*, such as the fact that *M. muscaedomesticae* is almost associated with flies as phoretic, are not observed in *M. similis*. In addition, *M. muscaedomesticae* reproduces by arrhenotokous parthenogenesis, whereas *M. similis* appears to be thelytokous. Furthermore, despite many specimens collected in Türkiye, no males of *M. similis*

were found. Therefore, Turkish specimens of *M. similis* are also thelythokous as reported by Halliday (1990).

DISCUSSION

The family Macrochelidae is quite well-known in the western Palaearctic, especially in Europe, compared to the other mesostigmatic mite families. There are many comprehensive papers on the systematics and species diversity of Macrochelidae species in this region (Evans and Browning, 1956; Krauss, 1970; Karg, 1971; Bregetova, 1977; Hyatt and Emberson, 1988; Mašán, 2003), but *M. similis* has not yet been described in this region. We collected 21 female specimens on the ventral side of a beetle (*Pentadon* sp.) in Antalya province in the Mediterranean region of Türkiye and many females freely in dung, soil and moss in Ekşisu Marsh in Erzincan province in eastern Türkiye. In conclusion, *M. muscaedomesticae* and *M. similis* are very similar based on their morphological features, so some researchers may not have been able to correctly identify the species; therefore, it would be appropriate to re-examine some specimens identified as *M. muscaedomesticae* in the Palaearctic.

Authors' contributions

Hasan Hüseyin Özbek: Methodology, identification, illustration, conservation, data collection, draft manuscript. **Furkan Durucan:** Collection of specimens, data collection, draft manuscript.

Statement of ethics approval

Not applicable.

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Conflict of interest

There is no potential conflict of interest.

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RESEARCH ARTICLE

A new zerconid mite (Mesostigmata: Zerconidae) from Southwestern Türkiye: *Zercon tripolisensis* sp. nov.

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ABSTRACT: Tripolis is one of the ancient cities in southwestern Türkiye. In a faunistic study of soil mites carried out here, a previously unknown species of the family Zerconidae was found in various plant litters and moss samples. Specimens of the new species were also found in two different locations except for their terra typica. All mature and immature stages of the new species, except for the larva, have been described and illustrated here. In addition, various data on the habitat preferences of the specimens found at the study sites were presented.

Keywords: Acari, Buldan, Denizli, description, new species, Tripolis

Zoobank: https://zoobank.org/A3DFF0A3-A802-4FA4-8511-EB4201EF27B7

INTRODUCTION

Türkiye is one of the countries where the diversity of Zerconidae has been best studied compared to other Holarctic countries. So far, 135 species of Zerconidae have been recorded from the different areas of Türkiye (Urhan and Karaca, 2023a) and new data on zerconid species are being added, especially through local or provincial faunistic studies. Most studies focus on the taxonomy of species or genera not only in Türkiye but also in other zoogeographic areas of the Holarctic (Kaczmarek et al., 2020, 2021; Urhan et al., 2020a-c; Bulut et al., 2021; Karaca, 2021, Keçeci et al., 2021; Marchenko, 2021, 2022; Moghimi et al., 2021; Bilki et al., 2022; Mohammad-Doustaresharaf et al., 2023; Urhan and Karaca, 2023a-c).

Tripolis ancient city is located in the Buldan county of Denizli province in southwestern Türkiye. The average altitude of this area above sea level is 200 meters. Although some vertebrate and invertebrate specimens have already been collected and reported from here (Yavuz and Aytek, 2020), there has been no study on soil mites in the ancient city. In this context, various biological materials were collected to investigate the diversity of soil mites in the ancient city. It is found that many materials contained several specimens of a new *Zercon* species described herein.

MATERIALS AND METHODS

Soil, litter and moss samples, which include specimens of zerconid mites, were collected from different habitats (Table 1) in the Tripolis Ancient City, vicinity of Yenicekent and Mahmutlu neighbourhoods, Buldan county of Denizli Province, between May 2018 and April 2019. The Garmin GPSmap 62s was used for taking information on sampling sites (coordinates and altitudes). All collected materials were carried to the acarology laboratory and later processed using a Berlese-Tullgren funnel with 25-watt fluorescent bulbs for 3-5 days. Totally 195 samplings were made in the study area.

Standard methods were used for sorting, measuring and drawing processes (Bulut et al., 2021). Widely accepted terminologies were used in identification processes for the specimens (Lindquist and Evans, 1965; Johnston and Moraza, 1991; Lindquist and Moraza, 1998). The holotype and paratypes of the new species, as well as the other Zerconidae specimens examined in this study were deposited in the PAU (Acarology Laboratory of the Department of Biology, Faculty of Science and Arts, Pamukkale University, Denizli, Türkiye).

All measurements including scale bars of the figures were given as micrometers (μm). Abbreviations of F, M, DN and PN were used for female, male, deutonymph and protonymph specimens, respectively.

RESULTS

Two species of *Zercon* were identified after examination of collected Zerconidae specimens from the research area. The first of them is described here as a new species for science, *Zercon tripolisensis* sp. nov. The second is *Zercon colligans*, a well-known and widespread species in Türkiye. Both species are listed below. In addition, some information (number of specimens examined, Turkish and worldwide distribution, and habitat preferences of the specimens) is given about *Zercon colligans*. With the new species, the number of zerconid mites known from Türkiye has increased to 136.

Family Zerconidae Canestrini, 1891

Genus *Zercon* C. L. Koch, 1836

Type species: *Zercon triangularis* C. L. Koch, 1836

Posterior part of peritremal shield ends with a blunt tip at the lower part of coxa IV. Peritremal shield with two setae: *r1* is short and straight, and *r3* is elongated, straight or finely barbed. There is a wide gap between peritremal shield and lateral edge of podonotum. Adgenital shield present with 2–5 opening valves. There are 7-8 pairs of marginal setae (*S1* + *R1–6* or *S1* + *R1–7*) on lateral edges of opisthonotum. There are one or two pairs of setae on the anterior part of ventroanal shield (setae *JV1* always present, seta *ZV1* present or absent).

Table 1. Overview of the habitat preferences of *Zercon* species in the study area.

Habitat types	*Z. tripolisensis* sp. nov.	*Z. colligans* Berlese
Anchusa azurea	✓	✓
Astragalus sp.	✓	✓
Cupressus sempervirens	✓	✓
Euphorbia kotschyana	✓	✓
Juniperus excelsa	✓	✓
Lolium perenne	✓	✓
Moss (unspecified)	✓	✓
Onopordum bracteatum		✓
Papaver rhoeas	✓	
Pinus brutia	✓	✓
Prunus amygdalus		✓
Pyrus elaeagrifolia	✓	✓
Quercus coccifera	✓	✓
Tragopogon dubius	✓	✓
Xanthium spinosum	✓	✓

Description of the new species

***Zercon tripolisensis* sp. nov.**

(Figures 1-7)

https://zoobank.org/46BBE88F-8DF5-4F2A-A0B5-BA31446BD822

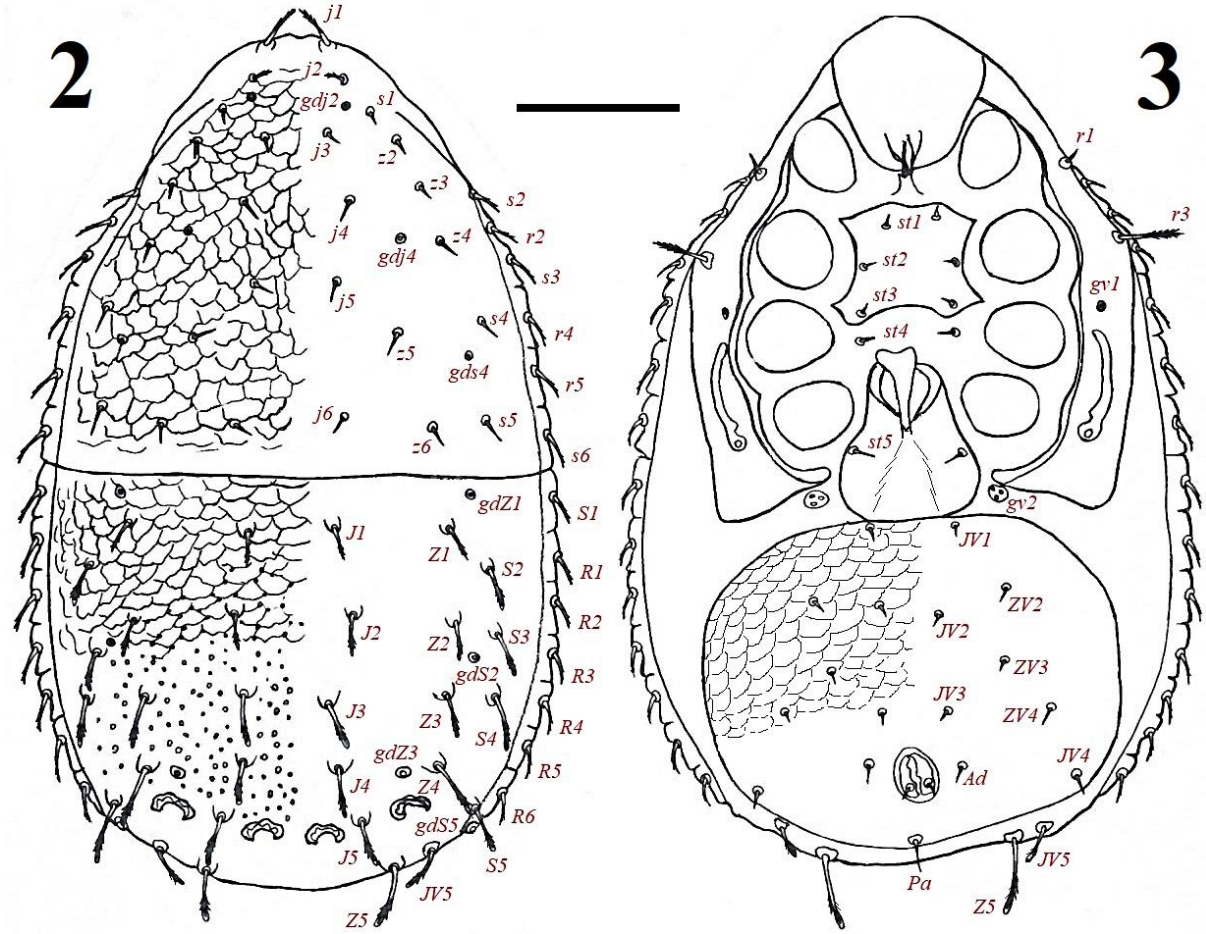
Type material. Holotype (F), soil and litter samples under *Quercus coccifera* (Fagaceae), 38°2.812' N, 28°57.463' E, 815 m a.s.l., vicinity of neighborhood cemetery, Tripolis ancient city, Buldan county, Denizli province, Türkiye, 16 August 2018 (Fig. 1). Paratypes: 257 F, 119 M, 87 DN, 49 PN, same data as holotype. 10 females, 29 males, 14 DN, 16 PN: soil and litter samples under *Quercus coccifera* (Fagaceae), 38°2.226' N, 28°57.466' E, 546 m a.s.l., vicinity of neighborhood cemetery, 18 June 2018. 135 F, 41 M, 22 DN, 11 PN: soil, litter and moss samples under various plants (Table 1), 38°2.106' N, 28°57.965' E, 600 m a.s.l., entrance of ancient city, 18 July 2018. 98 F, 51 M, 44 DN, 19 PN: soil and litter samples under *Pyrus elaeagrifolia* (Rosaceae), 38°2.368' N, 28°56.960' E, 668 m a.s.l., vicinity of ancient city walls, 17 September 2018. 192 F, 145 M, 56 DN, 25 PN: soil, litter and moss samples under various plants (Table 1), 38°2.324' N, 28°56.981' E, 651 m a.s.l., vicinity of ancient city bath, 18 October 2018. 155 F, 96 M, 50 DN, 32 PN: soil, litter and moss samples under various plants (Table 1), 38°2.670' N, 28°57.521' E, 620 m a.s.l., east side of ancient city, 15 November 2018. 47 F, 37 M, 11 DN, four PN: soil, litter and moss samples under *Lolium* sp. (Poaceae), 38°2.563' N, 28°56.913' E, 208 m a.s.l., vicinity of ancient city walls, 21 December 2018. 106 F, 86 M, 28 DN, 25 PN: soil, litter and moss samples under various plants (Table 1), 38°2.288' N, 28°57.287' E, 571 m a.s.l., vicinity of ancient city walls, 18 January 2019. 58 F, 49 M, 13 DN, 11 PN: soil, litter and moss samples under various plants (Table 1), 38°2.391' N, 28°56.947' E, 672 m a.s.l., vicinity of ancient theatre, 16 February 2019. 97 F, 122 M, 71 DN, 40 PN: soil, litter and moss samples under various plants (Table 1), 38°2.497' N, 28°56.794' E, 705 m a.s.l., vicinity of Hierapolis street, 21 March 2019. 27 F, 32 M, 71 DN: soil, litter and moss samples under various plants (Table 1), 38°2.698' N, 28°57.147' E, 862 m a.s.l., vicinity of necropolis areas, 15 April 2019. All samples were collected by Zhanerke Kassen from Tripolis ancient city. Seven F, four M, five DN, three PN: soil, litter and moss samples under *Quercus coccifera* (Fagaceae), 37°58.599' N, 28°48.411' E, 361 m a.s.l., vicinity of Kızıldere neighbourhood, Buharkent county, Aydın province, 2 February 2019, leg. Mehmet Karaca. One F: soil and litter samples under *Pinus brutia* (Pinaceae), 37°51.078' N, 28°52.953' E, 419 m a.s.l., vicinity Acıdere place, Acıpayam county, Denizli province, 12 February 2020, leg. Esat Enis Karnak.

Diagnosis. Anterior margin of ventrianal shield with two setae (seta *JV1* present, seta *ZV1* absent). Most of podonotal setae short, smooth and needle-like (except seta *j1–2* and marginal setae *s2–3*, *s6*, *r2* and *r4–5*). Setae *j1–2* and all marginal setae on podonotum finely barbed. Most opisthonotal setae elongated, finely barbed with hyaline endings (except marginal setae). Pores *gdS2* located between setae *Z2* and *S3 or Z2* and *S4*, *gdZ3* located between setae *J4* and *Z4*, closer to *Z4*. Dorsal cavities distinct and strongly developed. Podonotum and anterior margin of opisthonotum covered with tile-like patterns, mid-area to posterior margin of opisthonotum covered by irregular punctate patterns.

Female (Figs 2-3). Length (without gnathosoma) and width in holotype 468 and 302, respectively. Measurements of 10 paratypes: length 456–471, width 276–308.

Dorsal idiosoma (Fig. 2). Podonotal shields with 20 pairs of setae, including six pairs in *j* row (*j1–6*), five pairs in *z* row (*z2–6*), six pairs in *s* row (*s1–6*), and three pairs in *r* row (*r2* and *r4–5*). Setae *r1* and *r3* inserted ventrally, on peritrematal shields. Setae *j1–2* and all marginal setae (*s2–3*, *s6*, *r2* and *r4–5*) finely barbed, remaining podonotal setae short, smooth and needle-like. Setae *j1* obviously longer than the others. None of podonotal setae reaching the margin of posterior part of podonotum. Podonotal shield covered with tile-like patterns.

Figure 1. General view from the type locality of *Zercon tripolisensis* sp. nov. Tripolis ancient city (Photograph was taken on 16 August 2018 by Z. Kassen).



Figures 2-3. *Zercon tripolisensis* sp. nov. **2.** Dorsal view of female, **3.** Ventral view of female. Scale bar 100.

Table 2. Average lengths of opisthonotal setae and the distances between their insertions in *J*, *Z*, and *S* rows of *Zercon tripolisensis* sp. nov.

Setae	F	M	DN	PN	**Setae**	F	M	DN	PN	**Seta**	F	M	DN	PN
J1	20	12	7	8	***Z1***	20	12	10	10	***S1***	18	12	10	-
J1–J2	43	37	33	27	***Z1–Z2***	53	43	40	30	***S1–S2***	45	27	30	-
J2	22	14	8	5	***Z2***	22	14	10	6	***S2***	22	15	16	16
J2–J3	44	26	27	18	***Z2–Z3***	40	18	17	27	***S2–S3***	46	26	27	21
J3	28	16	9	5	***Z3***	30	23	24	18	***S3***	26	18	18	16
J3–J4	36	23	18	19	***Z3–Z4***	36	25	21	16	***S3–S4***	29	26	24	25
J4	29	14	10	5	***Z4***	38	37	42	40	***S4***	29	20	20	18
J4–J5	34	16	22	16	***Z4–Z5***	56	40	38	32	***S4–S5***	56	39	38	25
J5	29	11	9	4	***Z5***	32	34	46	45	***S5***	35	35	34	43

Opisthonotal shields with 21 pairs of setae, including five pairs in *J* row (*J1–5*), five pairs in *Z* row (*Z1–5*), five pairs in *S* row (*S1–5*), and six pairs in *R* row (*R1–6*). Most of opisthonotal setae elongated, finely barbed with hyaline endings (except marginal setae *S1* and *R1–6*). Setae *J1* and *Z1* similar in appearance and length, both of them finely barbed without hyaline endings. Setae *J2–5*, *Z2–5* and *S2–5* finely barbed with hyaline endings. In the marginal row, all setae finely barbed and shorter than the other opisthonotal setae. None of setae reaching the insertions of the following seta in *J*, *Z* and *S* rows. Setae *Z5* and *S5* reaching beyond margin of opisthonotum. The intervals between *Z5–Z5* 89–106 and *Z5–JV5* 24–31, respectively. Opisthonotal shield covered with tile-like patterns in anterior parts, remaining parts covered by irregular punctate patterns (Fig. 2).

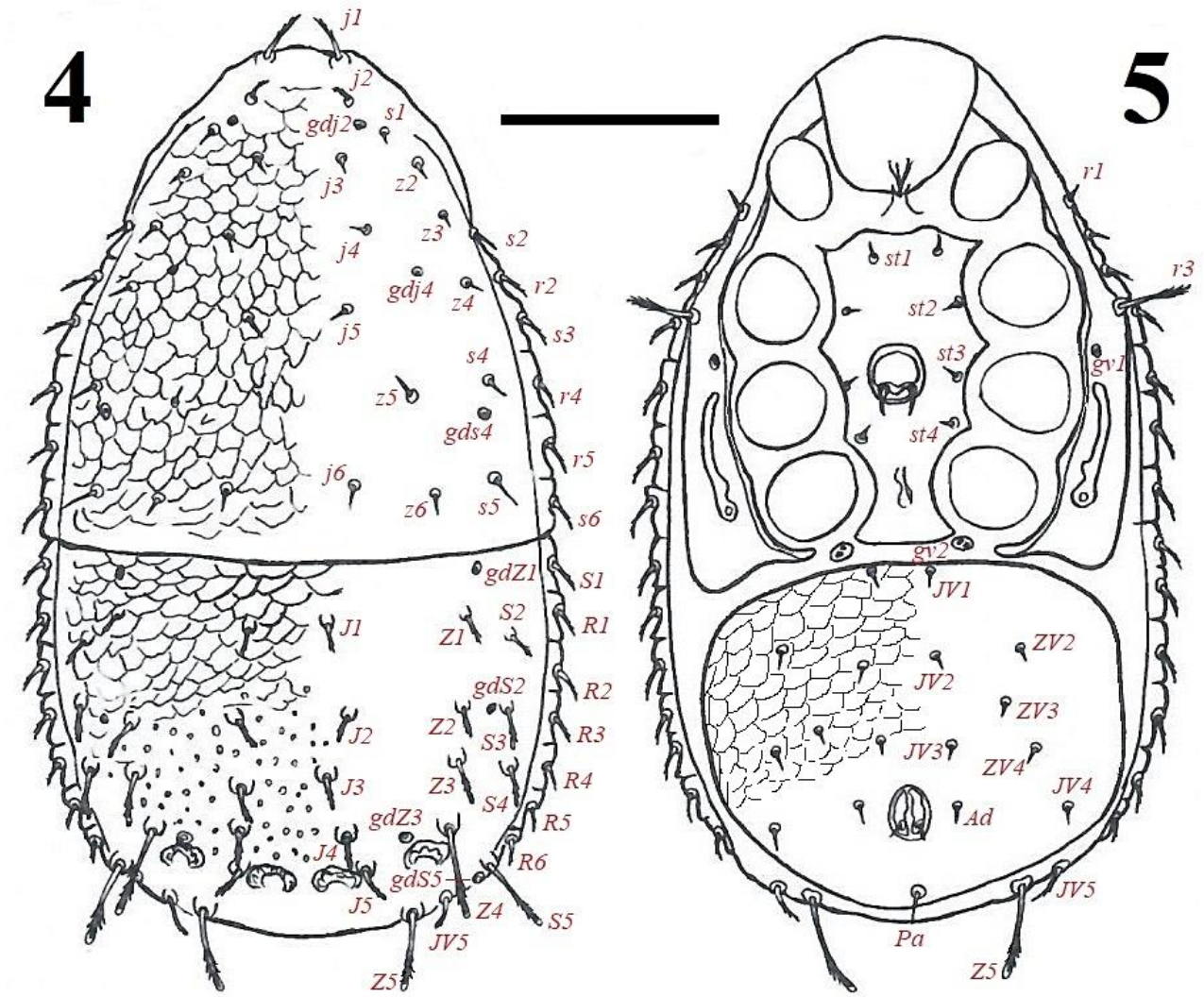
Gland pores *gdj2* located on the line connecting setae *j2* and *j3*, closer to *j2*, *gdj4* located on the line connecting setae *j4* and *z4*, closer to *z4*, *gds4* located on the line connecting setae *s4* and *z6*, closer to *s4*, *gdZ1* located above the insertion of seta *Z1*, *gdS2* located on the line connecting setae *Z2* and *S3* or *Z2* and *S4*, closer to *S2*, *gdZ3* located on the line connecting setae *J4* and *Z4*, closer to *Z4*, *gdS5* located below the insertion of seta *S5* (Fig. 2). All podonotal and opisthonotal gland pores about the same size.

Ventral idiosoma (Fig. 3). Posterolateral tips of peritrematal shield reaching the level of setae *S1–R1*. Chaetotaxy and ornamentation of peritrematal shield characteristical for *Zercon* species. Peritrematal shield with two pairs of setae (*r1* and *r3*), *r1* short, smooth and needle-like, *r3* elongated and finely barbed without hyaline ending. Peritreme slightly twisted anteriorly, and gland pore *gv1* located closer to anterior part of peritreme. Sternal shield with three pairs of setae (*st1–3*). Epigynal shield with one pair of setae (*st5*). Seta *st4* located between posterior part of sternal shield and anterior part of epigynal shield. All the above-mentioned setae (*st1–5*) short, smooth and needle-like. Gland pore *gv2* present between posterolateral part of epigynal shield and anterior part of ventrianal shield. Anterior margin of ventrianal shield with one pair of setae (seta *JV1* present, seta *ZV1* absent). Ventrianal shield with nine pairs of short, smooth and needle-like setae (*JV1–5*, *ZV2–4*, *Ad*), postanal longest, one pair of gland pores, and one single postanal seta (*Pa*). Seta *JV5* similar to opisthonotal setae *Z5* and *S5* in terms of shape, but shorter them. Gland pore *gv3* located closer to the insertions of adanal setae. Anterior part of ventrianal shield covered with squamous patterns, continuously extending the insertions of setae *JV3* and *ZV4* (Fig. 3).

Average lengths and distances of opisthonotal setae (*J*, *Z* and *S* rows) are given in Table 2 for F, M, DN and PN specimens of *Z. tripolisensis* sp. nov.

Male (Figs 4-5). Length and width of idiosoma 345–364 and 212–228, respectively (n=10). With an exception, chaetotaxy of idiosomal setae, location of gland pores on idiosoma and ornamentation of dorsal and ventral shields similar to those of females. Unlike female specimens, in which the opisthonotal seta *Z4* not reaching the beyond of opisthonotum, this seta reaching the beyond of opisthonotum in male specimens. Also, all podonotal and opisthonotal setae shorter than female specimens. Ventral idiosoma as in Figure 5. Distances between setae *Z5–Z5* 80–93 and *Z5–JV5* 13–19, respectively.

Deutonymph (Fig. 6). Length and width of idiosoma 326–350 and 228–238, respectively (n=10). Dorsal cavities uniform, equal in size, saddle-like and weakly sclerotised. Podonotal setae *j1*, *s3* and *s6* finely barbed, all the others short, smooth and needle-like. Only gland pore *gds4* visible on podonotum, located on the line connecting setae *z6* and *s4*, closer to *s4*. On opisthonotum, setae *J1–5*, *Z1–2* and *R3–6* short, smooth and needle-like. Setae *Z3–5* and *S3–5* finely barbed with hyaline endings. Remaining marginal setae (*S1* and *R1–2*) finely barbed without hyaline endings. Seta *Z3* reaching the insertion of seta *Z4*. Setae *Z4–5* and *S5* elongated, all of them reaching beyond margin of opisthonotum. Setae *S3* and *S4* similar in appearance and length. Four pairs of gland pores visible on opisthonotum, *gdZ1* located above the insertion of seta *Z1*, *gdS2* located on the line connecting setae *Z2* and *S3*, closer to *S3*, *gdZ3* located on the line connecting setae *J4* and *Z4*, *gdS5* located below the insertion of seta *S5*. The intervals between *Z5–Z5* 84-95 and *Z5–JV5* 12-18, respectively. Podonotum covered by irregular tile-like patterns, opisthonotum with irregular punctate patterns (Fig. 6).



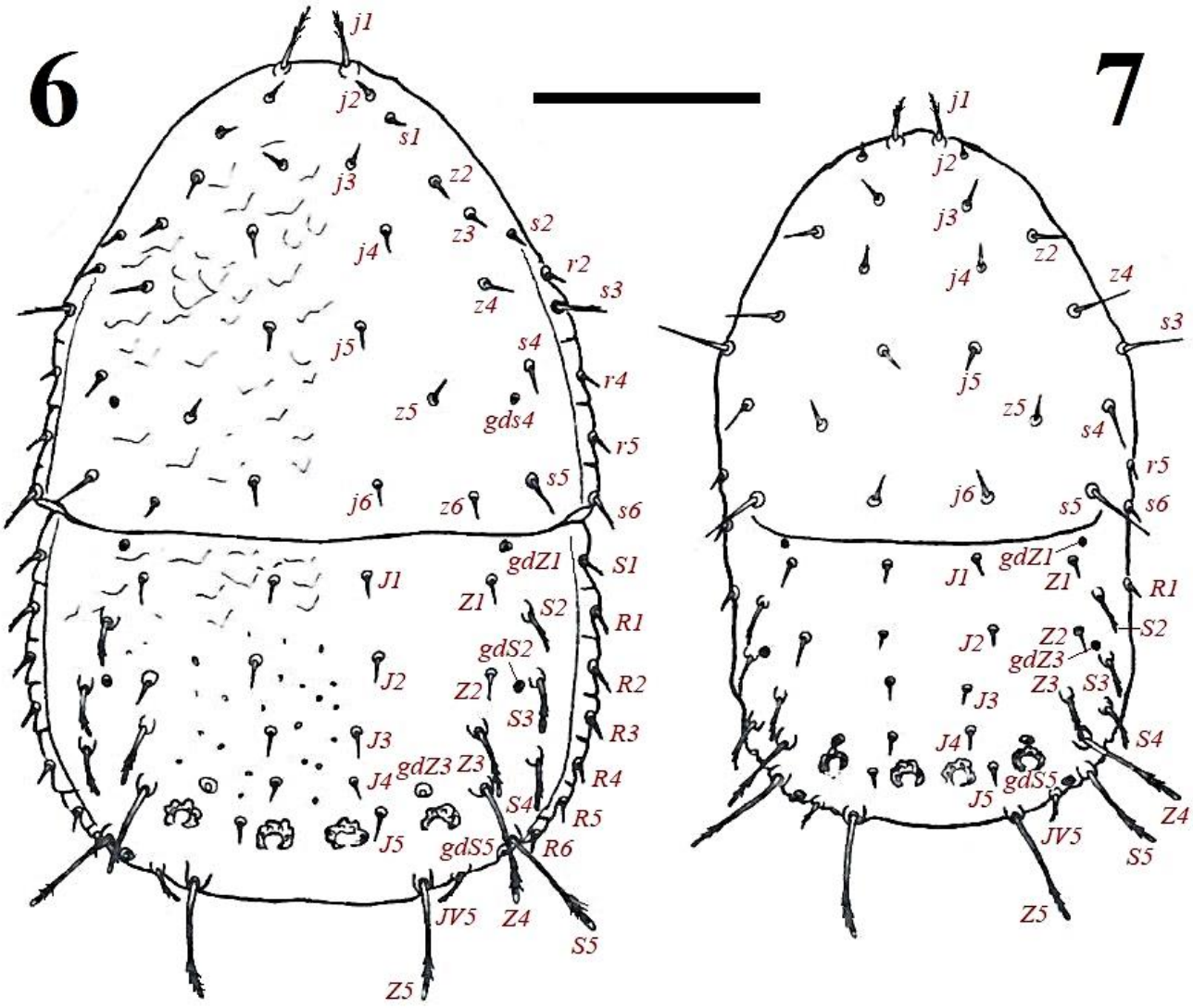
Figures 4-5. *Zercon tripolisensis* sp. nov. **4.** Dorsal view of male, **5.** Ventral view of male. Scale bar 100.

Protonymph (Fig. 7). Length and width of idiosoma 263–278 and 153–169, respectively (n=10). Features of dorsal cavities as in deutonymph specimens. All podonotal setae smooth and needle-like (except seta *j1*). Seta *j1* finely barbed. All gland pores invisible on podonotum. On opisthonotum, setae *J1–5*, *Z1–2* and *R1* short, smooth and needle-like. Setae *Z3–5* and *S2–5* finely barbed with hyaline endings. Remaining marginal setae (*S1* and *R2–6*) invisible. Seta *Z3* reaching the insertion of seta *Z4*. Setae *Z4–5* and *S5* as in deutonymph specimens, all of them elongated and reaching beyond margin of opisthonotum. Setae *Z3* and *S2–4* similar in appearance and length. Four pairs of gland pores visible on opisthonotum, *gdZ1* located above the insertion of seta *Z1*, *gdS2* located on the line connecting setae *Z2* and *S3*, *gdZ3* located on the line connecting setae *J4* and *Z4*, *gdS5* located below the insertion of seta *S5*. The intervals between *Z5–Z5* 56–71 and *Z5–JV5* 11–19, respectively. There is no pattern in both podonotum and opisthonotum (Fig. 7).

Larva. Not found.

Etymology. The specific epithet '*tripolisensis*' refers to the ancient city of Tripolis (Buldan County, Denizli province) where the new species was collected.

Remarks. *Z. tripolisensis* sp. nov. is quite similar to *Z. colligans* Berlese, 1920, *Z. kallimcii* Urhan, 2010 and *Z. turcicus* Urhan and Ayyıldız, 1994. These species have common morphological features as follows: most of podonotal setae short, smooth and needle-like, most of marginal setae both podonotum and opisthonotum finely barbed without hyaline endings, none of podonotal setae reaching the margin or beyond to posterior part of opisthonotum, opisthonotal setae *J1* and *Z1* smooth and needle-like (except *Z. tripolisensis* sp. nov.), opisthonotal setae *J3–5* and *Z3–5* finely barbed with hyaline endings, gland pore *gdS2* located closer to the insertions of setae *Z2–3* or *S2–3*, gland pore *gdZ3* located between *J* and *Z* setal rows, none of setae in *Z* and *S* rows reaching the insertions of the following setae in the same rows, dorsal cavities equal in size and parallel to transverse axis. On the other hand, the morphological distinguishing characters of these four species are given in Table 3, where all species are compared in terms of shapes of some setae on the podonotal and opisthonotal regions. Opisthonotal seta *JV5* is finely barbed with hyaline ending in *Z. tripolisensis* sp. nov. as well as *Z. kallimci*, but this seta is finely barbed without hyaline ending in *Z. colligans* and *Z. turcicus*. Compared with the other species in Table 3, presence of finely barbed without hyaline endings setae *J1* and *Z1* is an important distinguishing character for *Z. tripolisensis* sp. nov.



Figures 6-7. Dorsal views of immature stages of *Zercon dilekicus* sp. nov. **6.** Deutonymph, **7.** Protonymph. Scale bar 100.

Additional materials

***Zercon colligans* Berlese, 1920**

Materials examined: 421 F, 342 M, 192 DN, 109 PN: soil, litter and moss samples under various plants (Table 1), 38°2.812' N, 28°57.463' E, 815 m a.s.l., vicinity of neighborhood cemetery, 16 August 2018. 518 F, 291 M, 96 DN, 98 PN: soil, litter and moss samples under various plants (Table 1), 38°2.670' N, 28°57.521' E, 620 m a.s.l., east side of the ancient city, 15 November 2018. 52 F, nine M, four DN, two PN: soil, litter and moss samples under various plants (Table 1), 38°2.537' N, 28°57.343' E, 750 m a.s.l., vicinity of fortification wall of the ancient city, 15 April 2019.

Short description: Anterior margin of ventrianal shield with one pair of setae (seta *JV1* present, seta *ZV1* absent). On podonotum, setae *j1*, *r4–5* and *s6* finely barbed without hyaline endings, remaining podonotal setae smooth and needle-like. On opisthonotum, setae *J1–2*, *Z1–2* and *S2* smooth and needle-like, *S1* and *R1-6* finely barbed without hyaline endings, *J3–5*, *Z3–5* and *S3–5* elongated, finely barbed with hyaline endings, longer than other opisthonotal setae. Seta *JV5* similar in length and shape to marginal *R* setae. Only setae *Z5* and *S5* reaching to beyond of opisthonotum. Pores *gdS2* located between setae *J2* and *S3*, *gdZ3* located between setae *J4* and *Z4*. Dorsal cavities distinct and strongly developed. Podonotum and anterior margin of opisthonotum covered with tile-like patterns, mid-area to posterior margin of opisthonotum covered by irregular punctate patterns.

Distribution in Türkiye: Afyonkarahisar, Artvin, Aydın, Balıkesir, Çanakkale, Denizli, Edirne, Erzurum, Giresun, İstanbul, İzmir, Kırklareli, Kütahya, Manisa, Muğla, Tekirdağ, Uşak (Urhan and Karaca, 2022, 2023a-c).

Known distribution: Austria, France, Iran, Ireland, Italy, Russia, Sweden, Swiss, Türkiye (Urhan and Karaca, 2023a).

Habitat preferences of *Zercon* species in the study area

Samplings for *Zercon* species were carried out in 195 different localities and the following 18 habitat types, mostly herbaceous plant species, were noted: bugloss (*Anchusa azurea*), wormwood (*Artemisia annua*), milkvetch (*Astragalus* sp.), cypress (*Cupressus sempervirens*), spurge (*Euphorbia kotschyana*), fumewort

Table 3. Morphological distinguishing characters between *Zercon tripolisensis* sp. nov. and closer species within the same genus.

Characters	*Z. tripolisensis* sp. nov.	*Z. colligans*	*Z. kallimcii*	*Z. turcicus*
Podonotal seta *j2*	finely barbed	smooth	finely barbed	finely barbed
Opisthonotal setae *J1* and *Z1*	finely barbed	smooth	smooth	smooth
Opisthonotal setae *J2* and *Z2*	elongated, finely barbed with hyaline endings	short, smooth	elongated, finely barbed with hyaline endings	short, smooth
Opisthonotal seta *S2*	elongated, finely barbed with hyaline ending	short, smooth	elongated, finely barbed with hyaline ending	short, finely barbed without hyaline ending
Opisthonotal seta *S4*	not reaching to margin of opisthonotum	not reaching to margin of opisthonotum	reaching to beyond of opisthonotum	reaching to beyond of opisthonotum
Anterior margin of ventrianal shield	with two setae	with two setae	with four setae	with four setae
Seta *JV5* on ventrianal shield	with hyaline ending	without hyaline ending	with hyaline ending	without hyaline ending

(*Fumaria densiflora*), broom (*Genista anatolica*), Greek juniper (*Juniperus excelsa*), perennial ryegrass (*Lolium perenne*), moss (unspecified), cottonthistle (*Onopordum bracteatum*), common poppy (*Papaver rhoeas*), Turkish pine (*Pinus brutia*), almond (*Prunus amygdalus*), oleaster-leafed pear (*Pyrus elaeagrifolia*), kermes oak (*Quercus coccifera*), yellow salsify (*Tragopogon dubius*) and spiny cocklebur (*Xanthium spinosum*). Habitat preferences of *Zercon* species were marked in Table 1.According to Table 1, specimens of *Z. tripolisensis* sp. nov. and *Z. colligans* were found in 13 and 14 different habitat types, respectively. Although two different zerconid species were found due to the partially limited study area, there are many dates in the literature on *Z. colligans* individuals with broad habitat tolerance (Bulut et al., 2021; Karaca, 2021; Bilki et al., 2022; Urhan and Karaca, 2023). On the other hand, only individuals of a single zerconid were found in the habitats of cottonthistle, common poppy and almond. In addition, no individuals of any zerconid species were found in the habitats wormwood, fumewort and broom.

Authors' contributions

Raşit Urhan: Methodology, project administration, supervision, identification, illustration, preservation (supporting), data acquisition (equal), data analysis/interpretation (equal), critical revision of manuscript (equal), final approval and accountability (equal). **Mehmet Karaca:** Conception/design of study, collection of specimens (supporting), data analysis/interpretation (equal), drafting manuscript, critical revision of manuscript (equal), final approval and accountability (equal). **Zhanerke Kassen:** Collection of specimens (lead), data acquisition (equal), data analysis/interpretation (equal), preservation (lead).

Statement of ethics approval

Not applicable.

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Conflict of interest

Authors declared no conflict of interest.

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BOOK REVIEW

Türkçe olarak yeni yayımlanan *Genel Akaroloji* başlıklı kitaba genel bir bakış

"Doğan, S. ve Özman-Sullivan, S.K. (Ed.). 2023. *Genel Akaroloji*. Birinci baskı. Nobel Akademik Yayıncılık, Ankara, Türkiye, 716 s."

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ÖZET: Salih Doğan ve Sebahat K. Özman-Sullivan'ın editörlüğünde ilk detaylı kitap olarak yayımlanan *Genel Akaroloji*, hem araştırmacılar hem de eğitimciler için önemli bir akademik kaynaktır. Kitabın kapsamı ve titiz yaklaşımı, konu hakkındaki anlayışlarını geliştirmek ve derinleştirmek isteyen herkes için onu vazgeçilmez bir araç yapmaktadır. Bu kısa değinme, kitabın sunduklarının yalnızca yüzeysel bir incelemesidir.

Anahtar kelimeler: Acari, akar, inceleme, takdim, tanıtım, yayın

An overview of the book titled *General Acarology* recently published in Turkish

"Doğan, S. and Özman-Sullivan, S.K. (Eds). 2023. *General Acarology*. First edition. Nobel Akademik Yayıncılık, Ankara, Türkiye, 716 pp. [In Turkish]"

ABSTRACT: *General Acarology*, published under the editorship of Salih Doğan and Sebahat K. Özman-Sullivan, is the first detailed book on mites in Turkish. It is a great academic resource for researchers and educators alike. Its comprehensive coverage and thorough approach make it an essential tool for anyone seeking to develop and deepen their understanding on mites. This brief mention only scratches the surface of what this book has to offer.

Keywords: Acari, mite, review, presentation, introduction, publication

GİRİŞ

Her canlı grubu gibi akarlar da insanlığı daima kendilerine hayran bırakmıştır. Bu heyecan verici canlı grubunu konu edinen akarolojinin bir bilim dalı olarak doğuşu 20. yüzyılın başlarına denk gelir (Krantz ve Walter, 2009; Dhooria, 2016). Ülkemizde akarlarla ilgili ilk araştırmalar, 1920'li yılların sonunda kene kaynaklı hastalıklar üzerine yapılan bir çalışmayla (Hakkı, 1929) başlamış; bunu, kenelerle ilgili yapılan birkaç çalışma (Ör., Oytun, 1947; Kurtpınar, 1954) takip etmiştir. Bunun yanında, 1940'lı yılların ortalarına doğru başlayan tarımsal önemi olan akarlarla ilgili çalışmalar (Ör., Acatay, 1943; Alkan; 1947; Düzgüneş, 1952) göze çarpmaktadır. Türkiye'de akarlarla ilgili çalışmaların esas olarak 1980'li yıllardan sonra yoğunlaştığı ve günümüzde de devam ettiği söylenebilir. Osman Ecevit'in 1981 yılında yazdığı *Akarolojiye Giriş* adlı kitabı, bu sahada Türkçe yazılmış bir eserdir. *Genel Akaroloji* kitabı ise ülkemizde bu eserden sonra yazılan en kapsamlı eser niteliğindedir.

Genel Akaroloji kitabının farklı düzeydeki akademik araştırmalar yanında öğretim çalışmalarında da yararlı olacağı ve bu alanda önemli bir boşluğu dolduracağı kanısındayım. Güncel konuları kapsayan ve zengin bir kaynak taraması ve hâlihazırda kullanılmakta olan terim, kavram ve öne çıkan konulara geniş yelpazede yer verilen bu kıymetli çalışmanın içindeki bölümlere ve ihtiva etmekte olduğu konulara, ana hatlarıyla değinmenin, kitabı tanımak, kapsamı ve konulara yaklaşımları hakkında bilgi edinmek açısından yararlı olacaktır.

KİTABIN KÜNYESİ

Genel Akaroloji

Editörler: Doğan, Salih ve Özman-Sullivan, Sebahat K.

Yazarlar; Tablo 1'de listeli

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DEĞERLENDİRME

Geniş ve titiz bir kaynak taraması suretiyle hazırlanmış olan bu kitap, ülkemizdeki önemli bir boşluğu doldurmaktadır. Kitap, farklı alanlarda araştırma yapan ve yapacak olanlar için temel eser niteliği taşımaktadır.

Tablo 1. *Genel Akaroloji* kitabının yazar listesi (soy isim sırasına göre).

No	İsim ve Soy isim
1.	Rana Akyazı (Ordu Üniversitesi, Ordu, Türkiye)
2.	Recep Ay (Isparta Uygulamalı Bilimler Üniversitesi, Isparta, Türkiye)
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7.	Yunus Ömer Boyacı (Isparta Uygulamalı Bilimler Üniversitesi, Isparta, Türkiye)
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12.	İsmail Döker (Çukurova Üniversitesi, Adana, Türkiye)
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15.	Firdevs Ersin (Ege Üniversitesi, İzmir, Türkiye)
16.	Yunus Esen (Bingöl Üniversitesi, Bingöl, Türkiye)
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20.	Adem Keskin (Tokat Gaziosmanpaşa Üniversitesi, Tokat, Türkiye)
21.	Kamil Koç (Manisa Celal Bayar Üniversitesi, Manisa, Türkiye)
22.	Nabi Alper Kumral (Bursa Uludağ Üniversitesi, Bursa, Türkiye)
23.	Kosta Y. Mumcuoğlu (Kudüs İbrani Üniversitesi, Kudüs, İsrail)
24.	Hasan Hüseyin Özbek (Erzincan Binali Yıldırım Üniversitesi, Erzincan Türkiye)
25.	Sebahat K. Özman-Sullivan (Ondokuz Mayıs Üniversitesi, Samsun, Türkiye)
26.	Sedat Per (Kayseri Üniversitesi, Kayseri, Türkiye)
27.	Gregory Thomas Sullivan (Queensland Üniversitesi, Brisbane, Avustralya)
28.	Abdulkadir Taşdemir (Erciyes Üniversitesi, Kayseri, Türkiye)
29.	Ayşegül Taylan Özkan (TOBB Ekonomi ve Teknoloji Üniversitesi, Ankara, Türkiye)
30.	Ayşe Toluk (Erciyes Üniversitesi, Kayseri, Türkiye)
31.	Raşit Urhan (Pamukkale Üniversitesi, Denizli, Türkiye)
32.	Dürdane Yanar (Tokat Gaziosmanpaşa Üniversitesi, Tokat, Türkiye)
33.	Sibel Yorulmaz (Isparta Uygulamalı Bilimler Üniversitesi, Isparta, Türkiye)
34.	Erhan Zeytun (Erzincan Binali Yıldırım Üniversitesi, Erzincan, Türkiye)

Araştırmaların çok yoğunlaştığı, ciddi bir bilgi birikiminin oluştuğu ve akaroloji alanındaki boşluğun dikkat çekici boyutlara ulaştığı bir dönemde, böylesine konuları itibarıyla kapsamlı ve kuşatıcı bir yaklaşımla hazırlanmış nitelikli bir kaynağa ihtiyaç doğduğundan *Genel Akaroloji* kitabının bu doğrultuda önemli bir başvuru kaynağı olduğu kanısındayım. Yirmi yedi bölüm 716 sayfadan oluşan ve 190 şekil 29 tablo ile desteklenen bu kitabın, alanında uzman ve yetkin 34 bilim insanının katkısıyla ortaya çıkarılmış olduğu görülmektedir. Kitapta ayrıca 34 uzmanın kısaca akademik özgeçmişlerine de yer verilmiştir.

Akarolojinin tarihçesiyle başlayan bölümlerin; akarların kökeni, morfolojisi, anatomisi, embriyonik gelişimi, beslenme şekilleri, üreme davranışları, kimyasal haberleşme, yaşam ve taşınma şekilleri, mücadele yöntemleri ile sistematiği üzerinde durulmuştur. Bunun yanında, toprak akarları, su akarları, tarım, veterinerlik ve tıbbi açıdan önemi olan akarlar ile diğer omurgalı ve omurgasız hayvanların parazit akarları da birer bölüm halinde ayrıntılı olarak işlenmiştir. Yine akarlarda toplama, saklama, preparasyon ve inceleme teknikleri ile kriminal önemdeki akarların yanında, biyolojik çeşitliliğin korunması ve akarların durumu, akarolojide internet tabanlı araçlar gibi son derece güncel diğer konular, *Genel Akaroloji* kitabında üzerinde durulmuş temalar olarak dikkat çekmektedir. Akar sistematiğine beş bölüm ayrılmıştır. Bu bölümler; 'Ixodida', 'Mesostigmata', 'Trombidiformes', 'Sarcoptiformes', 'Opilioacarida ve Holothyrida' başlıkları altında ve takım düzeyinde tanıtıcı özellikleri ve sınıflandırmaları ile sunulmuştur.

Kitabın içinde yer alan bölümlere ve ihtiva etmekte olduğu konulara, ana hatlarıyla kısaca değinmenin, kitabı tanımak, kapsamı ve konulara yaklaşımları hakkında bilgi edinmek açısından yararlı olacaktır.

İlk bölümde; akaroloji tarihiyle ilgili ayrıntılı bilgiler verilmiş, gelişimine katkıda bulunan bilim insanlarının çalışmaları özetlenerek ayrıca Türkiye'deki gelişimi üzerinde durulmuştur. Bölüm, bir tablo ve bir şekille desteklenmiştir.

İkinci bölümde; akarların kökeni, evrimi, akar grupları arasındaki benzerlik ve fosil akarlar hakkındaki bilgiler toparlanmak suretiyle sunulmuştur. Fosil akar türleri için de bir tablo düzenlenmiştir.

Akarolojide öne çıkan konuların başında morfoloji ve anatomi gelmektedir. Bu konulara özel bir önem verilmiş; gnathozoma, gövde, deri ve ilişikli yapılar ile üyeler üzerinde durulmuş, verilen bilgiler yeni görüntüleme yöntemlerinin sunduğu verileri de kapsayacak biçimde sunulmuştur. Metin ayrıca toplamda 44 şekil ve üç tablo ile desteklenmiştir. Metinde kullanılan özelliklere uygun seçimler yapılmıştır. Sindirim, solunum, boşaltım, üreme, dolaşım, kas, sinir, duyu sistemleri ve bunların işlevsel bölge ve donatılarına ilişkin şekillerle desteklenmiş bilgiler verilmektedir. Güncel akarolojik terimlerin kullanılmasına özen gösterildiği dikkat çekmektedir.

Takip eden bölümde farklı akar gruplarındaki gelişim ve başkalaşım hakkında bilgi verilmiş, yumurta ve bölünme tipleri, prelarva, larva, protonimf, deutonimf ve tritonimf evreleri üzerinde durulmuştur. Bu bölümde üç şekil verilmiştir.

Su akarlarına ayrı bir bölüm açılmış olduğu görülmektedir. Bu bölümde akrabalık ilişkileri, sınıflandırma, hayvan coğrafyası, morfolojik ve anatomik özellikler yanında sistem bilgileri, gelişim evreleri, yaşam alanları ve ekolojileri hakkında bilgi verilmiştir. İki tablo ve 12 şeklin yer aldığı bölümde özellikle Türkiye su akarları üzerinde durulmuştur.

Tarımsal önemi olan akar familyalarına özel bir bölüm ayrılmak suretiyle önemleri vurgulanmıştır. Bu bölümde Tetranychidae, Penthaleidae, Tenuipalpidae, Tarsonemidae, Eriophyidae, Phytoptidae, Acaridae ve Carpoglyphidae familyalarının öne çıkarıldığı görülmektedir. On beş şekille desteklenen bu bölümde ayrıca Türkiye'de zararlı olan 42 akar türünün morfolojik ve biyolojik özellikleri hakkında bilgiler verilmiştir.

Veterinerlik açısından önemi olan akarlara ait bilgilerin sunumunda bir tablo ve 23 şekilden yararlanılmıştır. Bölümde Sarcoptiformes (iki familya), Trombidiformes (dört familya), Mesostigmata (dört familya) ve Ixodida (iki familya) üzerinde durulmuştur. Kenelerin biyolojileri, ekolojileri ve vektörlüklerine dikkat çekilmiş, konu seçiminde çiftlik hayvanlarının yanında, kedi, köpek, at ve deve gibi hayvanları etkileyen akar grupları öne çıkarılmıştır.

Tıbbi önemi olan akarlar başlığı altında; Argasidae, Cheyletidae, Demodecidae, Dermanyssidae, Ixodidae, Macronyssidae, Pyemotidae, Sarcoptidae ve Trombiculidae familyalarına ait örnekler üzerinde durulmuş; ayrıca depolanmış ürün akarları, hayvanların parazit akarları başlıkları açılmış ve bunların biyolojisi, epidemiyolojisi, partenogenezi, yaşam döngüleri, immuniteleri ve bu akarlar ile bulaşan bazı hastalıkların klinik durumları, tanıları, tedavileri, korunma ve kontrolleri üzerinde ayrıntılı bilgilere yer verilmiştir. Bu bölüm ayrıca altı tablo ve 22 şekille desteklenmiştir.

Omurgalı ve omurgasız hayvanlardaki parazit akar takımlarından (Trombidiformes, Sarcoptiformes, Mesostigmata ve Ixodida) seçilmiş türlerin parazitik ilişkileri üzerinde durulan bölümde, bir tablo ve beş şekil yer almaktadır. Genel bir çerçeveden yaklaşılarak hazırlanan bölümde, veterinerlik ve tıbbi nitelikte olan akarların dışında kalınarak konu tekrarından kaçınıldığı anlaşılmaktadır.

Kriminal önemdeki akarların krimino-hukuk araştırmalarında kullanılması temalı bölümde bir adet tablo düzenlenmiş, adli işlemlerde kullanılan akarlar, olayların aydınlatılmasındaki önemleri, kullanılma yöntemleri, kullanılmalarının avantaj ve dezavantajları ile uygulamalarda dikkat edilmesi gereken hususlar üzerinde durulmuştur.

Akarlarda kimyasal haberleşme bölümünde üç tablo yer almaktadır. Bu bölümde semiokimyasallar üzerinde durulmaktadır. Konakçı bitki-akar, parazit akar-konakçı, parazit-avcı akar ilişkileri ve akar feromonları hakkında bilgiler yer almaktadır. Bölümde, parazit ve diğer akar gruplarıyla mücadelede kullanılan bilgi taşıyıcı kimyasallar hakkında ayrıca ayrıntılı bilgiler verilmektedir.

Ayrı bir bölümde bazı Mesostigmata, Ixodida, Opilioacarida, Holothyrida, Trombidiformes ve Sarcoptiformes akar türlerinin beslenme şekilleri üzerinde ayrıntılı bilgiler verilmektedir.

Akarlarda üreme davranışları ayrı bir bölüm halinde hazırlanmış ve bu bölüm üç şekille desteklenmiştir. Akarlarda eşeyli üreme, partenogenez, çiftleşme, erkek dişi ilişkileri, eşeysel seçilim, ebeveyn bakımı, davranış modellerinin evrimi temaları üzerinde güncel bilgiler yer almaktadır.

Akarların taşınması konusunda; su, hava, forezi ve diğer taşınma şekilleri hakkında bilgiler verilmiştir. Bu bölümde

üç şekilden yararlanılmıştır. Sonuçlar alt başlığı ile bazı hususlara dikkat çekilmek istenmiştir.

Akarların birlikte yaşam şekilleri, bir tablo ve iki şekil eşliğinde parazitizm, kommensalizm, mutualizm, predasyon ve rekabet alt başlıkları altında tür düzeyinde örneklerle anlatılmıştır.

Akarların sosyal yaşam tipleri; yuva davranışları, av-avcı ilişkileri, erkek-dişi ilişkileri alt başlıkları altında bilgilendirilmiş ve bölümde bir de şekil kullanılmıştır.

Zararlı akarlarla mücadele yöntemlerini konu edinen bölümde; Prostigmata alt takımından Eriophyidae, Tarsonomidae, Tenuipalpidae ve Tetranychidae familyalarına ait tarımda önemli zararları olan türler üzerinde durulmuştur. Bir tablo ile desteklenen bölümde, bu gruplar için yapılan mücadele yöntemlerinin kültürel önlemler, kimyasal, biyolojik ve diğer bütünleşik mücadele şeklinde uygulanmakta olduğu vurgulanmıştır.

Ayrı bir bölümde akarların toplanma, saklanma, preparasyon ve inceleme şekilleri hakkında bilgiler verilmektedir. Çok farklı yaşam alanlarına sahip olan akarların bu tür işlemleri de önemli farklılıklar arz etmektedir. Bu durum dikkate alınarak bitki ve hayvanlardan, su, toprak ve ev tozlarından toplanan akarların geçici ve daimi preparatlarının yapılması, incelenmesi, çeşitli inceleme araç ve gereçleri, çizim ve diğer görüntüleme teknikleri üzerinde durulmaktadır. Bu bölümde 12 şekil yer almaktadır.

Kitapta 'Sınıflandırma' başlığı altında ayrı bir kısım oluşturulmuş, burada farklı bölümler altında akarların taksonomik bilgilerine yer verilmiştir. Bu bölümlerin ilkinde Opilioacarida ve Holothyrida takımlarının tanımları yapılmakta, sınıflandırmaları, yayılış, habitat ve ekolojik durumları hakkında bilgiler verilmektedir. Ayrıca cinsler için teşhis anahtarları düzenlenmiş olan bölümde beş adet şekil bulunmaktadır.

Kenelerle ilgili olan diğer sınıflandırma bölümünde; Ixodidae, Argasidae, Nuttalliellidae, Deinocrotonidae, Khimairidae familyalarının tanıtıcı özellikleri verilmiş ve sınıflandırılması yapılmıştır. İki tablo ve altı şeklin yer aldığı bu bölümde, familyalar ile Türkiye'den tespit edilen cinsler için teşhis anahtarları düzenlenmiştir.

Mesostigmata bölümünde, takımın tanıtıcı özellikleri verilmiş ve sınıflandırılması yapılmıştır. Alt takım Sejida, Trigynaspida, Monogynapsida'nın tanıtıcı özellikleri verilmiş, kohort ve familya düzeyinde teşhis anahtarları düzenlenmiştir. On bir adet şekille bu özellikler desteklenmiştir. Kohort, üst familya, familya anahtarlarının yanında her familyadaki cins ve tür sayılarına da yer verilmiştir.

Diğer bir sınıflandırma bölümünde, Trombidiformes takımının tanıtıcı özellikleri verilerek sınıflandırması yapılmıştır. Bu bölümde dokuz adet şekilden yararlanılmış olduğu görülmektedir. Üst kohortlar için teşhis anahtarları düzenlenmiş, familyalar verilerek bunlardaki cins ve tür sayıları kaydedilmiştir.

Sonraki sınıflandırma bölümde, Sarcoptiformes takımının tanıtıcı özellikleri özetlenmiş ve sınıflandırmaları yapılmıştır. Alt takım Endeostigmata ve Oribatida hakkında taksonomik bilgiler verilmiştir. Bölümde yedi adet şekil kullanılmıştır. Üst familyalar için teşhis anahtarları düzenlenmiş, cins adları ile ihtiva etmekte oldukları tür sayıları verilmiştir.

Kitabın sonunda, 'Özel Konular' başlığı altında iki bölüme yer verilmiştir. 'Biyolojik Çeşitliliğin Korunması ve Akarlar' konulu ilk bölümde, genel bir değerlendirme yapılarak olaylar bütüncül yaklaşımla sunulmuştur. Burada kitlesel yok oluş, biyolojik çeşitlilikteki azalmanın nedenleri, korunması ve alınması gereken önlemler üzerinde durulmuştur. Akarların biyolojik çeşitlilikteki önemine vurgu yapılarak Uluslararası Doğayı Koruma Birliği ve Akar Uzmanlar Grubundan söz edilmektedir.

Son bölümde, akarolojide internet tabanlı kullanılan 25 araç tespit edilmiş, bunların adlarını ve adreslerini ihtiva eden bir tablo düzenlenmiştir. İçerikleri ve kapsadığı konular ve gruplar hakkında bilgiler verilmiştir. Bu bölümde, araçların güncel bilgilere hızlı bir biçimde ulaşmada önemli yararlar sağladığı vurgulanmaktadır.

SONUÇ

Ülkemizde akaroloji alanında Ecevit (1981) tarafından yayımlanan *Akarolojiye Giriş* adlı kitaptan sonra ikinci ve en kapsamlı kitap olan bu eserin, akademik, eğitim ve öğretim çalışmalarına önemli katkısının olacağı kanısındayım. Kitapta işlenen konular, okuyucunun anlama gücünü artırmak amacıyla etkin ve verimli bir şekilde sunulmaya çalışılmış, konuların sunum sırası öğrenim hedeflerine uygun şekilde hazırlanmıştır. Kitapta anlaşılır bir dil kullanılmaya özen gösterilmiş, sözcük seçimi ve terminoloji kullanımı konusunda hassas davranılmıştır. Kitap hazırlanırken bilimsel ve terminolojik terimlerin Türkçe karşılıkları kullanılmış, bunun yanında orijinalleri de parantez içerisinde gösterilmiştir. Görsel içeriği zengin olan kitapta çok sayıda orijinal fotoğraf ve çizimler kullanılmış, alıntı yapılan telifli şekil ve görseller için kullanım izinleri alınarak metinde telif bilgilerine yer verilmiştir.

Mevcut yerli ve yabancı akaroloji kitapları içinde konularının kapsamı, güncelliği ve farklı konularda sunmakta olduğu bilgi yoğunluğu itibarıyla ileri bir düzeyin yakalanmış olduğu görülmektedir.

Ülkemizdeki akaroloji alanındaki araştırmaların daha iyi duruma gelebilmesi için farklı disiplinlerdeki araştırmacıların katılımlarını sağlamak ve doğru bir zeminde onlarla güç birliği yapmak suretiyle bu tarz eserler ortaya koymak çok önemlidir ve görüldüğü üzere bu başarılmıştır. *Genel Akaroloji* kitabı, bu yaklaşımın güzel örneklerinden birinin kanıtı olarak siz değerli okuyuculara ulaştırılmaktadır.

Kitaba ilişkin değerlendirmeler, olumlu ve olması gereken doğrultuda yapılmıştır. Diğer türlü sonuç ve yaklaşımları zamana bırakmak lazımdır.

Uyumlu bir çalışmayla ortaya çıkan *Genel Akaroloji* kitabının akademik camiaya faydalı olmasını dilerim.

Etik onay beyanı

Gerekli değildir.

Çıkar ilişkisi

Çalışma ile ilgili herhangi bir çıkar ilişkisi bulunmamaktadır.

Teşekkür

Son cümlelerimi, bu kitabın özverili bir çalışmanın ürünü olduğunu vurgulayarak hazırlanmasında emeği geçen herkese şükranlarımı sunmaya ayırıyorum. Şahsıma ilk okuma fırsatını vererek değerlendirmeme imkân sağlayan Salih Doğan'a (Erzincan Binali Yıldırım Üniversitesi) ve Sebahat K. Özman-Sullivan'a (Ondokuz Mayıs Üniversitesi) teşekkür ederim.

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